Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 16
JULY
1943
No. 7

INCLUDING *Aviation Instruments*

MOISTURE

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Grain . . . Tobacco . . . and Wartime Substitutes

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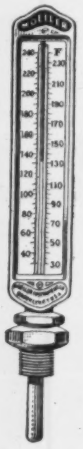

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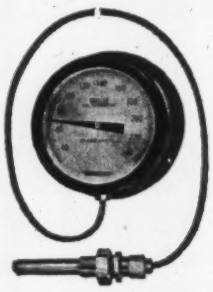

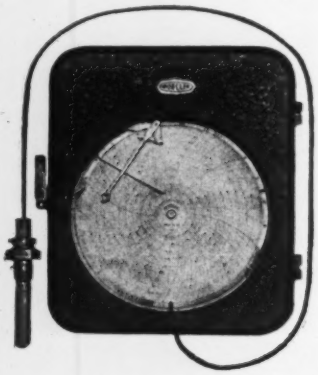

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EDITORIAL

Speaking of Control . . . on the Blackboard

OFFICE MEMORANDUM

FROM: President, Instruments Pub. Co. DATE: June 5, 1943
TO: Editor, INSTRUMENTS

1. It is just ten years since you were promoted from Engineering Editor to Editor of INSTRUMENTS. The Company hereby . . .

2. Of greatest permanent value, however, has been your constant work in shaping and refining the standard terminology of instrumentation. The Company suggests that in your June (tenth anniversary) editorial you publish in full your automatic control terms and definitions. If this notice is too short, print the list in the July issue. Current events over which the Company has no control make advisable the earliest possible re-publication of this standard. R. R.

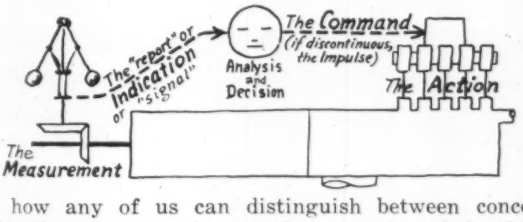
OFFICE MEMORANDUM

FROM: Editor, INSTRUMENTS DATE: June 5, 1943
TO: President, Instruments Pub. Co.

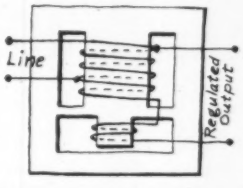
1. Suggestion is appreciated and will be carried out in a modified form—a sort of brief chalk talk. It will be for our 6000 new (since P.H.) subscribers—not for the busy wordsmiths, some of whom are outstanding experts.

2. To "sell" the complete Standard Terminology to other "language grouns" would require reprinting several chapters and articles and printing the revised Appendix IV for the first time—a total of some sixty pages. The mere list cannot sell itself to other "language groups." It probably would not stem the rising tide of superfluous new names in the literature over which our Company has no control. And that is the very point: we have never sought to control what is printed elsewhere; we have never denied the right of any "language group" to call its terminology THE standard one; we have only done our own job. M.F.B.

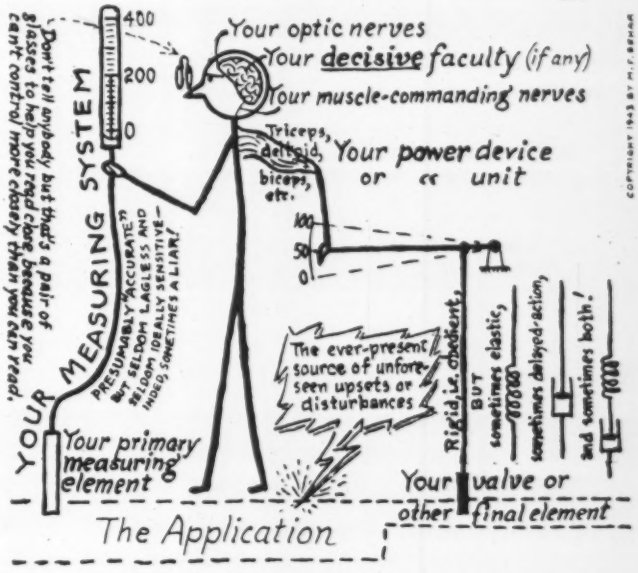
EXPERTS please leave the room. Thank you. Now, men, the language of Instrumentation is largely drawn from various branches of science and engineering but it has to be distinct and the first thing one must learn is to be wary and alert when hearing or reading other languages (all made up of English words). A "potentiometer" turns out to be a resistor; a "meter" an indicator; a "colorimeter" a color comparator. We read that "the quantity is registered on a meter" but it turns out that the weight is indicated on a spring-scale. In particular, the literature on automatic-control devices is being issued in many different languages. One reason is that some writers either don't know the standard language or deliberately give to already-named things and concepts the names of *other* things and concepts. A second reason is the legitimate desire of manufacturers to enjoy the advantages of registered trade-marks (somewhat like in the fields of pharmaceuticals, plastics, etc.). A third reason is that certain things and concepts were developed simultaneously in different fields, so that one certain small instrument is a speed controller to a chemist, a speed regulator to an electrician, a governor to a mechanician and perhaps a velostat to a physicist or an r.p.m. limiter to an aircraftsman. We instrumenticians would call it by *any* of these five names, depending on the field of application, but would sometimes put "automatic" in front of "controller" or "regulator." We're only dealing with *automatic* controllers or regulators in this informal chat. In fact, we're trying to speak of automatic control or automatic regulation—concepts apart from things. This first blackboard sketch



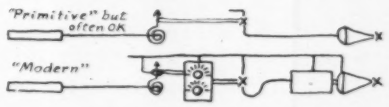
shows how any of us can distinguish between concepts (attributes, properties, characteristics, etc.) and the things to which they relate. We can't learn the names of all the parts of the marvelous valve-sequencing hydraulic system, so we deal with abstractions common to all automatic controllers — even to those without moving parts. (That's how the standard terminology of Instrumentation began. Perhaps that's why it is the standard.) At the other extreme from a complex turbine governor is a small Sola voltage regulator as shown in the second sketch. In a way, it is ideal for our purpose because it has no moving parts. Yet it is made up of elements which measure the variable to be controlled, which remember the exact value to be maintained,



and which perform the requisite corrective action in about 1/30 second! (Electronic automatic volume controls and static neutralizers work even faster.) Now let's go back to automatic controllers with moving parts, particularly to the instrument types which perform miracles in many industries today—and to-morrow will help shape an industrial civilization with a fifth freedom: freedom from useless manual drudgery. Yes, they are a crowning glory to instrumentation, but we don't have to be Einsteins to understand them. Here's the proof:


Your optic nerves
Your decisive faculty (if any)
Your muscle-commanding nerves
Triceps, deltoid, biceps, etc.
Your power device or "unit"
400
200
0
100
50
0
YOUR MEASURING SYSTEM
Don't tell anybody but that's a pair of glasses to help you read clear because you can't control more closely than you read.
PRESUMABLY "ACCURATE" BUT SELDOM LAGLESS AND SELDOM IDEALLY SENSITIVE— INDEED, SOMETIMES A LIAR!
The ever-present source of unforeseen upsets or disturbances
Rigid, i.e. obedient,
BUT sometimes elastic,
sometimes delayed-action,
and sometimes both!
Your primary measuring element
Your valve or other final element
The Application
COPYRIGHT 1943 BY M. F. BENNS

Don't laugh at this cartoon; study it. Don't admire it; criticize it. In some ways it is correct (it is the revision of a 1925 idea which advanced the art); in other ways it is wrong: it doesn't show, for example, what the brain does. Well, what can the brain do? In general, send commands based on what the eyes see: on the indication. The indication must not be falsified by drag and the orders must be carried out obediently, so here are some improvements:



Ideally, the corrective action at the final element would be related to the true instantaneous value of the controlled variable—specifically to its departure or deviation from normal. With this ideal in view, the important performance characteristics of automatic controllers were classified in 1930 as four relations:

(1) Extent of departure to extent of corrective action;
(2) Extent of departure to rate of corrective action;
(3) Rate of departure to extent of corrective action;
(4) Rate of departure to rate of corrective action. (This is not like No. 1, because of non-linearities.)

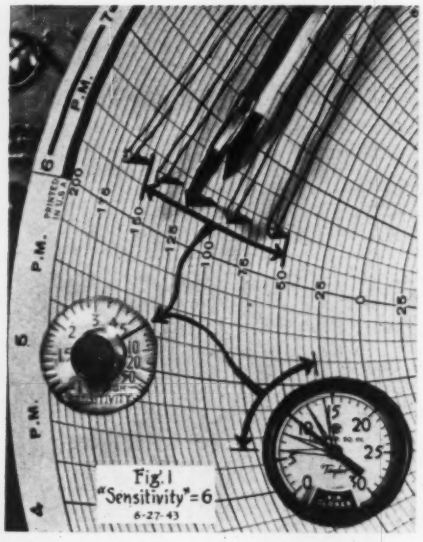
Note that these four important performance characteristics or "curves" are the relations between

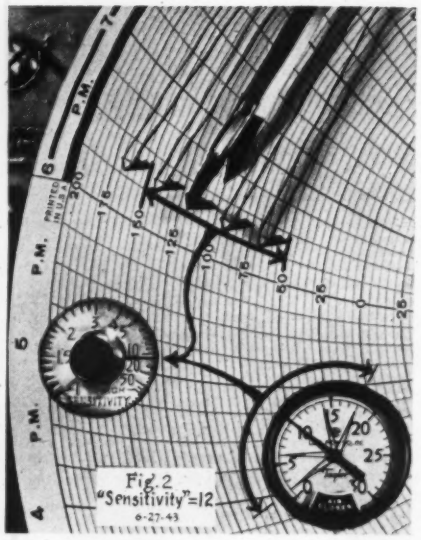
departures or deviations of the true value of the controlled variable (not of the position of a pointer, pen-arm, etc.)

and

the change in rate of flow of energy or of controlled medium (not the change in position of a valve, rheostat, etc.)

In 1930 it was too difficult and costly to plot these performance characteristics as a standard practice and etch curves on the name-plates of all controllers. Even today, it is prohibitive. So they were not named when they were first published: they were held up as an ideal. But let's forget these "overall characteristics" for a moment and let's consider specifically the decisions and commands of the brain. In an automatic-control system, *(Concluded on page 438)*





"On-the-job" Adjustments of Air-operated Recorder-controllers

By J. G. ZIEGLER

Taylor Instrument Companies, Rochester, N. Y.

EDITOR'S NOTE.—At the top of the first page of his manuscript, the author typed the following: "Statements and opinions advanced in this blurb are to be understood as individual expressions of the author and not necessarily those of *Instruments*. On second thought we delete 'necessarily.'—MFB" This is the first time that an *Instruments* author has suggested the wording—or even the general nature—of an editorial introduction. Since it is similar, on the whole, to the usual editorial statement introducing an article expressing strong opinions, we print it without altering a word of it—not even the word "blurb" (which means a publisher's announcement of a book and doesn't mean an article). Yes, we thank Mr. Ziegler for handing us these twenty-nine words already typed! BUT . . . this prepared statement is incomplete because it implies that the following article has not been edited. Of course, none of Mr. Ziegler's *assertions* has been altered but, as has been the routine of this sanctum for ten years, some of the unfamiliar special terms used in his manuscript have been translated into the standard Instrumentation language—into the terminology familiar to our subscribers because *Instruments* has made its authors use it during the last ten years. Not all of Mr. Ziegler's special terms have been translated—only those which are strange and confusing new names for things or concepts which our subscribers know by their familiar standard names. We have NOT translated some Ziegler terms which, although new to our subscribers, are genuinely useful in conveying to the reader's mind the valuable advice contained in his article. Moreover, the twenty-nine words give the impression that we condescend to accept his article when the fact is that one year ago we heard about his "practical dope on adjustments" and immediately asked him to let our subscribers have it.—MFB

PART ONE—"PROPORTIONAL SENSITIVITY" OR "THROTTLING RANGE"

PRESENT-DAY air-operated automatic controllers are ingenious gadgets and are made adjustable. If the best control results are to be obtained, the best adjustments must be found for each job and they must be found *on the job*. Determinations of adjustments are often time-consuming, especially for the beginner, but they need not be. In fact the beginner who follows a definite adjustment procedure will generally arrive at correct adjustments in considerably less time than an experienced instrument man following a cut-and-try system. It is important to realize the goal of adjustment; to realize when the optimum performance is being obtained and then not waste time striving for better results when it means pursuing a will-o'-the-wisp.

In spite of the many different air-operated automatic-control mechanisms on the market, all are basically similar as far as their comparable actions are concerned. In this article, therefore, we will deal with them in general—and not with any one particular mechanism—and we will forget intricacies of mechanisms and deal only with essentials common to all makes. (It may be necessary for the reader to identify the corresponding adjustment on different makes: A study of the instrument instruction book will usually disclose which adjustment produces the result in question.)

Most air-operated controllers have a "pointer" or "pen-arm" or "index," actuated by the measuring element, which *indicates* the scale value of *the controlled variable* such as temperature. We will call this device the PEN. They also have a part which, although shaped like a pointer, is not actuated by the measuring element but is "positioned" or "set" by the user at the SETTING-POINT on the scale. We will call this part the SETTING-ARM. Air-operated controllers have two little pressure gages. One is for checking the correctness of the pressure from the air compressor; we can forget it (as the user often does). On the other little gage, the user reads the air pressure from the controller mechanism to the controlled valve or damper, but we can forget these details and think only of this reading as the OUTPUT of the mechanism.

The first adjustment we shall consider is such a simple one that it is most often called a setting. All air-operated controllers have some means of regulating the output pressure so that it will have a certain value when the pen is at the setting point (when pen and setting-arm *coincide*). This is known as setting for "mid-point" or for "axis" or for "normal valve opening" or, simply, as ZEROING the output. Thus, in Fig. 1 and 2, the controller has been "zeroed" for 10 lbs./in.^{2}. Controllers can generally be set to give any output pressure (within the range of the compressed-air supply) with pen and setting arm coincident.

The only other adjustment we will consider is sensitivity. No, not the sensitivity of the measuring system but "CONTROL SENSITIVITY" and specifically "PROPORTIONAL SENSITIVITY" which we will call sensitivity for short. This requires first a little explanation of "PROPORTIONAL."

Nearly all manufacturers make only two types of air-operated controllers, the type which gives a "proportional"

mode of control and the type which gives a "proportional plus reset" mode of control. In this article we will consider only the former type of controller but we will not go into details of modes of control which would mean delving into highbrow considerations of the entire control system: we will consider only what the user of a controller can observe readily while he stands before the panel-board.

The PROPORTIONAL characteristic.—All air-operated controllers produce this "response." It does just what this name implies: gives output pressure changes proportional to movement of the pen. In Fig. 1, for example, the control instrument is set so that each five divisions of pen movement gives an output change of 2 lbs./in.^{2}. Moving the pen up five units increases the output from 10 to 12 lbs.; another five units raises it to 14 lbs. and so on to the limit of supply pressure. Similarly, downward pen movement reduces the output pressure proportionally. For any intermediate pen position there is a corresponding output pressure.

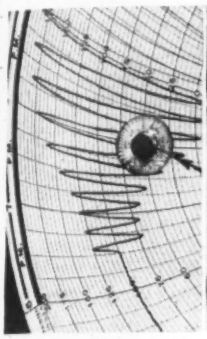


Fig. 3

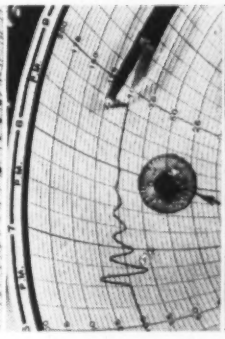


Fig. 4

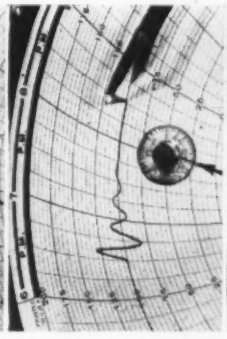


Fig. 5

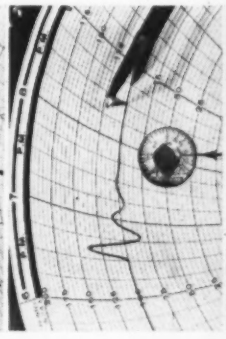


Fig. 6

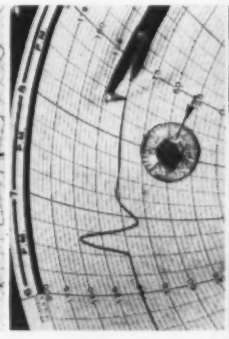


Fig. 7

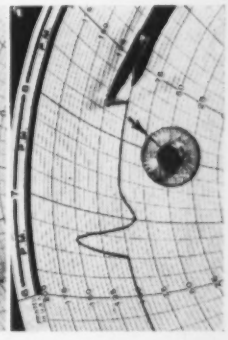


Fig. 8

(It is generally possible in air-operated controllers to reverse the action so that pen movement in one direction either increases or decreases the output. The action must be set so that the output change is applied to the process in the direction which tends to stop the pen movement. This, however, is fixed for any one job so does not really constitute an adjustment.)

SENSITIVITY ADJUSTMENT

Proportional control instruments also have another adjustment for varying the *amount of output change per unit pen movement.* Fig. 2 shows the same instrument as Fig. 1 but adjusted for twice the sensitivity. Each five divisions of pen movement now gives an output change of 4 lbs./in.^{2} instead of two. It is with this sensitivity adjustment that we are primarily concerned.

In order to compare the sensitivity of different controllers, let us apply a unit which will not vary with the width of scale graduations. The chart scale of Figs. 1 and 2 (the original, not the illustration) has 15 divisions per inch; so we can say that the sensitivity in Fig. 1 is 6 lbs./in.^{2} *per inch of pen movement;* and, in Fig. 2, the sensitivity is 12 lbs./in.^{2}/in. Some controllers of the so-called high-sensitivity type do not have sensitivity adjustment; it is fixed at about 1000 lbs./in.^{2}/in. (1 lb./in.^{2} for each 0.001" of pen travel). Others have a limited adjustment from 1000 down to about 40 lbs./in.^{2}/in. Generally the adjustment will be found to cover a range from 1000 to about 2 or 3 lbs./in.^{2}/in.

The task of finding the correct sensitivity adjustment on the job is often facilitated if the relative sensitivity at different positions of the adjusting mechanism is known. Some manufacturers calibrate this adjustment in terms of sensitivity directly; others in terms of "THROTTLING RANGE" which is reciprocally related to sensitivity. One is as good as the other as long as it is remembered that cutting the throttling range in half is the same as doubling the sensitivity.

Sensitivity values on instruments without calibrated dials may be quickly determined. It is a good idea to do this for each type of instrument to be adjusted; not necessarily to all instruments of the same type. To calibrate, adjust to the lowest sensitivity (or widest throttling range) and with the indicating element (pointer or pen) fixed at some point on the scale, move the setting-arm exactly one inch on the scale. (It is easier to move the setting-arm than to push the pointer or pen around.) Note the output change which occurs. If the output went from 7 to 10 lbs./in.^{2}, the sensitivity is obviously 3 lbs./in.^{2}/in. Repeat at several higher sensitivity adjustments. As higher values are checked, the inch of setting-arm movement will call for output changes beyond the limits of supply pressure. Then move the setting-arm enough to make a 10-lb. change, say from 3 to 13. Measure the setting-arm movement required and divide 10 lbs./in.^{2} by this distance in inches. A setting-arm movement of ¼" would indicate a sensitivity of 10/¼" or 40 lbs./in.^{2}/in.

Remember, the Proportional Characteristic is as described above, regardless of the controller make. The only difference will be in the mechanism used and possibly in the linearity of the characteristic. Nor does the Sensitivity Adjustment have a different effect if it is called Throttling Range. Only the numbers on one dial go up as the others go down. The mechanism for sensitivity adjustment may be different, the range of sensitivity covered and the ease and continuity of adjustment may be different, but it is still a sensitivity adjustment.

STABILITY

So far we have looked only at a control instrument—specifically, one with adjustable sensitivity of its proportional characteristic. Now let us hook this controller up to an average process and observe, on this same instrument, the effect of varying the sensitivity. We will apply identical "DISTURBANCES" to the same process, varying only the sensitivity adjustment. The disturbance will be comparable to opening the by-pass around the controlled heat-supply valve for a few moments, thereby adding a slug of heat to the process. Figs. 3 to 8 show the resulting "RECOVERY CURVES" traced by the pen.

Look first at Fig. 6. For the average control application it represents the optimum stability. The decreased sensitivities of Figs. 7 and 8 give greater periods of oscillation and greater initial deviation. In Figs. 5 and 4, increased sensitivity produces less stability, shorter periods and less initial deviation. In Fig. 3 the sensitivity has been increased to a point at which sustained oscillation results—in other words, constant hunting. In still other words, an amplitude ratio of unity.

STUDY THE WIGGLES!

A useful measure of stability is called the "Amplitude Ratio" which is simply the amplitude of one swing of the pen, divided by the amplitude of the preceding swing in the same direction. Refer to Fig. 6 in which the first downward swing amounts to 56°, and second to 14°. The amplitude ratio is then 14/56 or 0.25. The amplitude ratio in Fig. 5 is 0.4 and in Fig. 7, about 0.08. The amplitude ratio of 0.25 in Fig. 6 is normally the best because of all the recovery curves, this one encloses about the least area. In other words the pen is away from the setting point *the least distance for the least time.*

There are cases in which an amplitude ratio other than 0.25 is to be preferred. If initial deviation is more important than the

time required for recovery to stable control, the wiggle of Fig. 5 might be desirable. If the more extreme movements of the controlled heat-supply valve, caused by the controller as adjusted in Fig. 6, upset later parts of the process, and if deviation is not as important as stability, the lower sensitivity of Fig. 7 or even Fig. 8 might be preferable. Liquid-level control of surge tanks is a good example of this case. But in general an amplitude ratio of 0.25 is most desirable.

LOAD ERROR (OR "DROOP" OR "OFFSET")

The curves of Figs. 3 to 8 were initiated by a sudden disturbance; just a shot of heat. The output pressure required after the disturbance died out was in all cases the same as before it occurred. But usually the reason for having a controller in the first place is to try and limit the deviations which would otherwise be caused by changing flows into and out of the process. All of these disturbances which are not momentary but are sustained and which require changes in controller output are called "load changes." The size of a process load change can be measured by the difference in outputs before and after the load change.

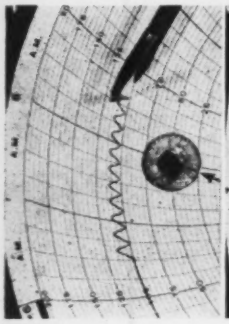


Fig. 9

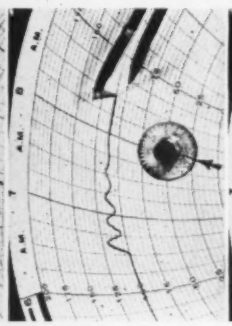


Fig. 10

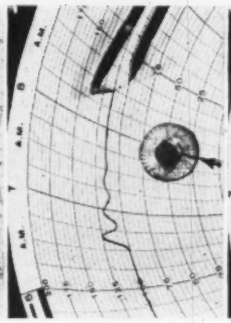


Fig. 11

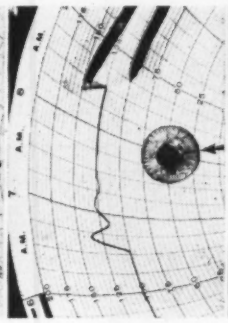


Fig. 12

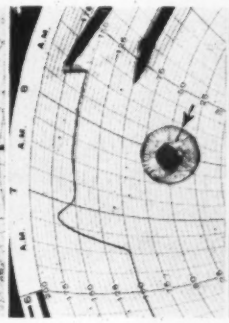


Fig. 13

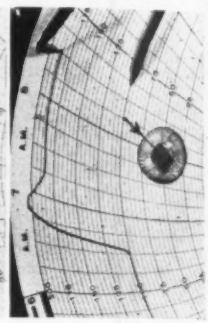


Fig. 14

A proportional type controller set to give one output when the pen is at the setting-point can only produce a different output if the pen moves away from the setting-arm. The effect of a sudden load change on our process is shown on Figs. 9 to 14 inclusive. Note that in order to make the required output change of about 3 lbs./in.^{2}, the pen settles out away from the setting-arm. Also note that the distance between pen and setting-point (or between pen and setting-arm) increases as the sensitivity is lowered: it varies about in proportion to the lowness of sensitivity. This distance would, of course, vary in proportion to the size of the load change and therefore is often called the LOAD ERROR. (It is known also by other names, among them "droop" and "offset.") Cutting the sensitivity in two doubles the load error for the same load change. In adjusting the sensitivity, therefore, one must weigh *two* factors, stability and load error. Fig. 12 represents our optimum sensitivity regarding stability and the 3-lb. load change gives a load error of about 24° at this sensitivity setting. An increase in sensitivity from 10 to 16 as in Fig. 11 decreases the load error to 15° but at the same time decreases the stability to a dangerous degree. A reduction in sensitivity (Fig. 13) increases stability but increases the load error. So the final sensitivity adjustment must be simply a compromise between stability and load-error. Usually the oscillation with an amplitude ratio of 0.25 still represents about optimum conditions of stability and load error. This stability is then generally the goal to shoot for. Keep the curves of Figs. 9 to 14 in mind when adjusting sensitivity so that time will not be wasted in searching for an adjustment which will give more stability with less load error.

The curves of Figs. 3 to 14 were purposely made with large periods and amplitudes of oscillation to show their shape more clearly. The same pattern holds for processes giving small amplitudes or short periods or both. Also, sensitivity is relative; a value of 100 may be low for one process while a sensitivity of 1 or 2 (lbs./in.^{2}/in.) may be too high for another. We might have a process which gave oscillations only one-tenth as large as those pictured and have a much shorter period. This process might give an amplitude ratio of 0.25 at a sensitivity of say 100 instead of 10, but reducing the sensitivity to 20 would have the same effect on stability as the reduction from 10 to 2 on the pictured process.

After the correct sensitivity adjustment is found, the zero (or mid-point or axis) adjustment must usually be made so that pen and setting-arm agree at the normal load. For example if the controller output is around 10 lbs./in.^{2} most of the day and the load goes to 12 lbs./in.^{2} once in a while for a short time, the instrument would normally be zeroed for 10 lbs./in.^{2}. If the load error were too large during the time the 12-lb. load prevailed, or if the load were at each value for about an equal time, the instrument might be set for 11, so that half the load error occurred on each side of the setting point. At different loads a load error is bound to occur and can only be corrected on this type of controller by a zero adjustment made each time a load change occurs. (This might be called "manual reset" as against another controller characteristic called "automatic reset" or "automatic droop correction" which performs the operation automatically.)

"ON-THE-JOB" EXAMPLES

We are now ready to adjust a proportional type controller on another job. Before starting to twiddle adjustment knobs, let us establish one thing. Can the job stand wide oscillations during the time necessary to make the adjustment? If so, our task is easier and time will be saved. Let us run an adjustment chart on this basis and then take the case where disturbances must be held to a minimum.

Fig. 15 shows a typical chart during adjustment. The process was first running under manual control, that is, with the controlled heat-supply valve shut off and the "by-pass" valve set to hold the temperature at about 100°, the desired point. At 8:30 a.m. (lower right-hand corner), the automatic controller was turned on, the by-pass closed and the controller sensitivity set at the highest possible value, which in this case was 1000 lbs./in.^{2}/in.

The hunting which ensued showed no signs of diminishing by 9:30 a.m., so the sensitivity was reduced to 100. This made no apparent difference and at 10:15 a.m. it was further reduced to 50. This cut the amplitude somewhat but the amplitude ratio was still 1.0 (sustained oscillation). At 11:15 a.m. the sensitivity was reduced to 20, which produced a damped oscillation. It was decided at 1:30 p.m. to check the adjustment, so a disturbance was created by turning the setting-arm up to 125° for a few seconds. The resulting oscillation was too small to readily show stability, so a larger disturbance was made at 2:00 p.m. by leaving the setting-arm at 125° for a longer period of time. The amplitude ratio was so nearly 0.25 that no further adjustment of sensitivity was required. The setting-arm and pen did not agree by about 3°, so a zero adjustment was made at 3:15 to bring pen and setting-arm together with the required output which happened to be 9 lbs./in.^{2}.

It sometimes happens that the best sensitivity adjustment is not found at first try. Hours or days later, when the controller is working at a different load, stability may decrease even to the point of giving sustained oscillation. If this occurs it simply means that another determination of sensitivity must be made. For ex-

ample, if the sensitivity of 20 found in Fig. 15 later gave less stability and a new determination established that a sensitivity of 10 was required to give the best amplitude ratio, it would mean that the sensitivity had to be adjusted to 10 in order to give stability under the more difficult load condition. Many otherwise fine instrument men have driven themselves to drink just because they tried to readjust sensitivity every time a load change occurred instead of finding the lowest required value and realizing that it was the best adjustment. The sensitivity must always be adjusted to a value low enough to give stability under the *worst* load condition. For this reason it is a good idea to keep a record of sensitivity adjustments found on each job. For example, the process of Fig. 15 might be excessively stable the day following the first adjustment and a check show that a sensitivity of 40 was correct. A glance at the notebook would show this value to be excessively high when the load returned to the original value so the sensitivity would be left at 20.

curve was quite stable, indicating that the sensitivity could be raised.

At this point, time spent in calibrating the sensitivity adjustment starts to pay off. Even though care is necessary on this job we know that a large increase in sensitivity can be made because the 8:00 a.m. stability is even greater than that in Fig. 9, and on that process the sensitivity was made five times as high before the required stability of Fig. 6 was obtained. So we are perfectly safe in doubling the sensitivity. Accordingly adjustment to 4 lbs./in.^{2}/in. was made and a disturbance created at 9:15. The disturbance was hardly large enough but it could be observed that the stability was still excessive, so the sensitivity was again doubled to 8 at 9:45. This recovery curve began to show a little

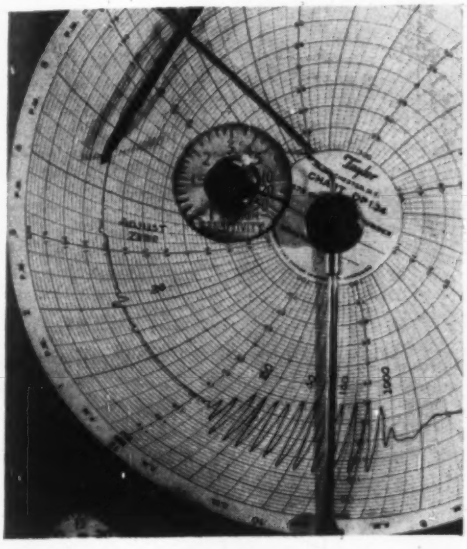


Fig. 15

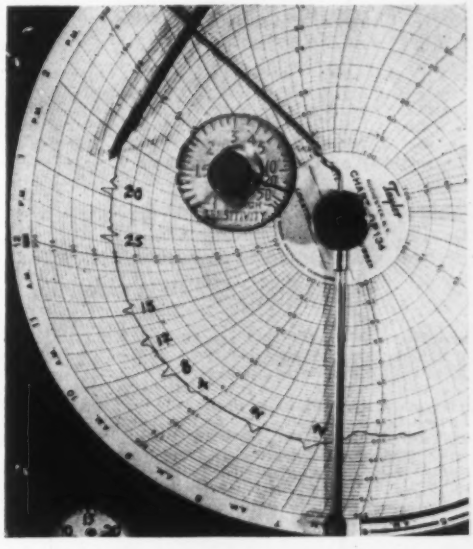


Fig. 16

When excessive oscillation cannot be tolerated during adjustment, more care must be exercised. Fig. 16 shows a typical adjustment chart on such a job. The process was under manual control until 6:45 a.m., at which time the controller was put in operation. It was adjusted to the low sensitivity of 2 lbs./in.^{2}/in. and the zero adjusted for 8 lbs./in.^{2} with pen and setting-arm together since this gave the estimated required opening of the controlled valve or damper. When the controller was cut on at 6:45, the temperature started to rise, indicating that the estimated valve opening was excessive, so the setting-arm was moved to a lower temperature in order to close the valve somewhat. By cut-and-try manipulation of the setting-arm, the temperature was brought back near 100° at which time the output was observed to be 9 lbs./in.^{2}. The setting-arm was placed behind the pen and the zero adjusted for 9 lbs./in.^{2} instead of 8.

At 8:00 a.m. a disturbance was made by temporarily moving the setting-arm up to 150°. This gave an increased valve opening for a short time. The resulting recovery oscillation so the next increase at 10:20 was only to 12, further raised to 15 at 11:00 a.m. The amplitude ratio of 0.1 was still short of that desired so the sensitivity was increased to 25 at 12:15 p.m. This increased the amplitude ratio too much so the sensitivity was dropped to 20 and checked. At this point an amplitude ratio of about 0.25 resulted. Since the instrument had already been zeroed for 9 lbs./in.^{2}, pen and setting-arm agreed. Note that the sensitivity adjustment found by this method was exactly the same as that determined by the less careful procedure.

Don't be in awe of automatic controllers: they are common-sense gadgets and not the least bit mysterious. Remember the foregoing picture of proportional control and its sensitivity when you must adjust an instrument; study the instructions to identify the principal adjustments on the particular mechanism, then walk right up and adjust the controller. Follow one of the recommended procedures and see if better results are not obtained more quickly than by cut-and-try methods.

Parts 2 and 3, on other adjustments, will appear in an early issue.

Cover Photo: Monsanto's Texas City Styrene Plant

In this control room the most minute operation is recorded and adjustments are made in the manufacture of styrene, one of the raw materials essential to making Buna-S synthetic rubber. This control room is in the dehydrogenation unit at the Texas City, Texas, styrene plant which was built and is operated as part of the government's fast-developing synthetic rubber program.

The distillation tower which stands the equivalent of a twenty-story office building is the plant's major unit.

The Texas City plant was designed, built and is being operated by Monsanto Chemical Company. It was brought from basic construction to production in the period of seven days less than one year. (The first tank car of styrene left Texas City on March 10, 1943. Basic construction had begun on March 17, 1942.) Soon, the plant will produce a large part of all styrene required in the government's synthetic rubber program.

Recovery-curve Graphs for Properly Adjusting Air-operated Automatic Controllers

To the Editor of *Instruments*:

After delving into some of the mathematics of process control, I found that I obtained a much better general idea of the proper adjustment of pneumatic-relay type automatic control instruments by the use of a series of graphs representing the changes in "output pressure" away from the "control pressure" when a load change occurs in the process being controlled.

[EDITOR'S NOTE.—The "output pressure" is the pressure from the pilot air valve to the controlled diaphragm-motor valve at any instant; the "control pressure" is the particular value of the output pressure necessary to hold the temperature (or other controlled variable) at the setting-point or "control point."—M.F.B.]

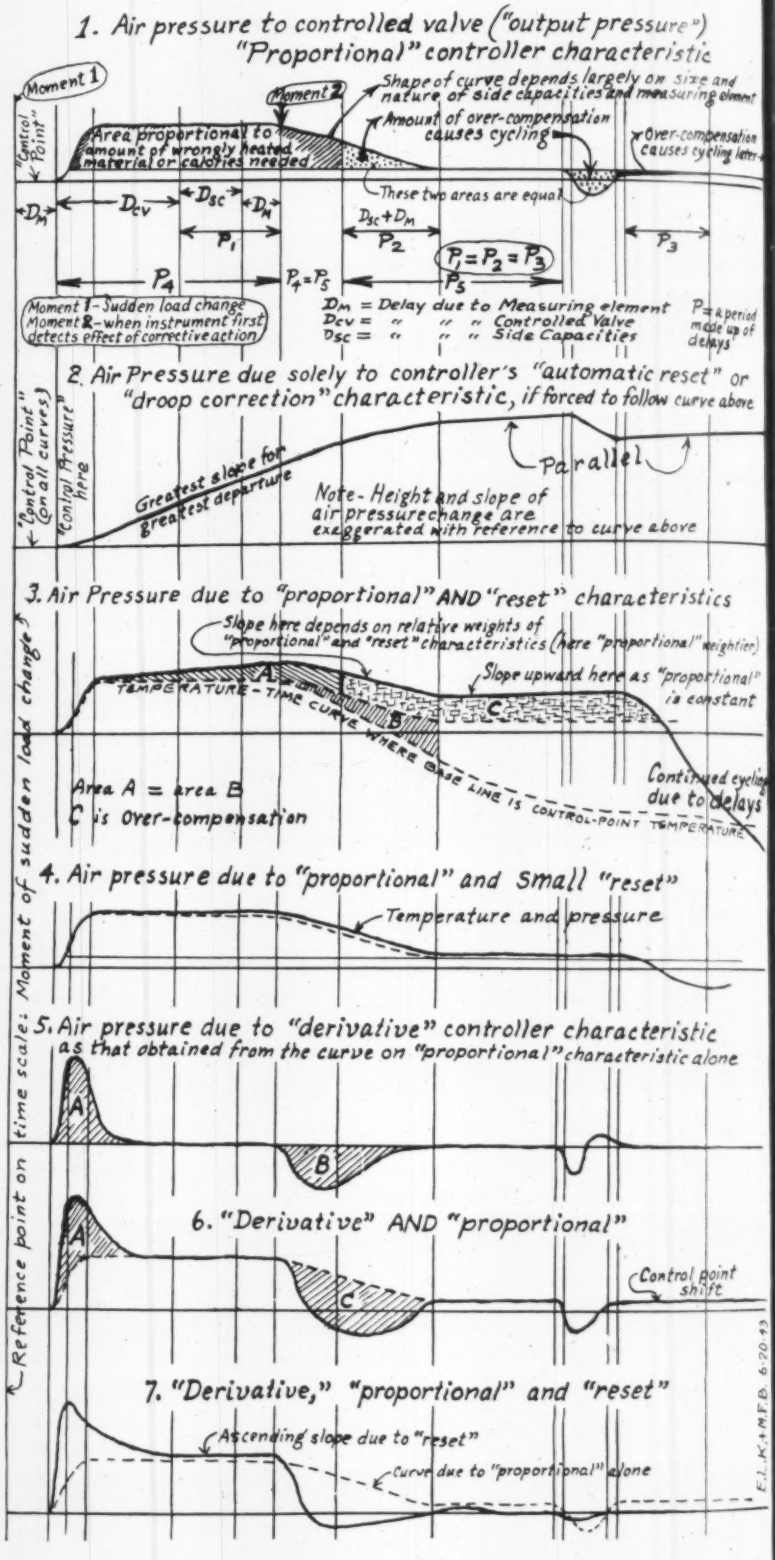
These graphs having helped me to obtain better results, I am submitting them in the hope that you will consider them sufficiently helpful to other subscribers to be worth printing.

[EDITOR'S NOTE.—We did not accept Mr. Kumm's graphs as first submitted because some of the terms in his original captions were so new and strange to us that we could not understand them and—since they had never been used in *Instruments*—we naturally believed that most of our subscribers would not understand them either. We faithfully traced Mr. Kumm's *graphs*, but in the *lettering* we made several substitutions and numerous additions. Mr. Kumm has fully approved all of our alterations and additions. He has approved also our changes of terminology in his letter.—M.F.B.]

The type of automatic controller which is the subject of this study is made by various firms under various names. It is neither the simple on-off type nor the simple proportional-corrective-action type but the more elaborate type with "automatic reset" and "derivative" characteristics. Instrument men will recognize these three control-instrument characteristics or responses: Taylor Instrument Companies' "Sensitivity," "Reset," and "Preact"; Foxboro's "Proportional Band" and "Hyper-Reset" ("reset rate" and "derivative" action together), Leeds & Northrup's "Throttling Range" and "Droop-Correction," and so on for other manufacturers.

It is important to notice mainly two items in Fig. 1 which represents the curve for the output pressure due to the "proportional" characteristic of the automatic controller. These two items are: (1) the corrective action which is proportional to the load change which acts only so long as the measuring device tells it to act and (2) an inevitable amount of over-compensation which will cause cycling. In this curve (Fig. 1) it should also be noted that we get a final output pressure whose difference from the original control pressure is directly proportional to the load change. The curve shown is the output pressure, but in a "straight-proportional-acting" controller, it also will represent the action of the indicating element (i.e., the pointer) away from the control point. Thus, when a load change comes along, it is necessary for the indicating pointer to move away from the "control pointer" or "setting arm" of the control instrument so that this instrument will detect that it is not on the control point and thus may maintain a control pressure different from that before the load change. Now, if the load change is rather permanent, the instrument man should properly set the setting-arm and indicating pointer together for the new output pressure.

If the load changes are many, it may be necessary to have the instrument automatically resetting itself. This reset action gives an additive rate of change of output pressure change proportional to the deviation of the measuring


1. Air pressure to controlled valve ("output pressure")
"Proportional" controller characteristic
Moment 1
Moment 2
Shape of curve depends largely on size and nature of side capacities and measuring element
Amount of over-compensation causes cycling
Over-compensation causes cycling later
"Control Point"
Area proportional to amount of wrongly heated material or calories needed
These two areas are equal
D_M
D_{cv}
D_{sc}
D_M
P_1
$D_{sc}+D_M$
P_2
$P_1=P_2=P_3$
P_3
P_4
$P_4=P_5$
P_5
Moment 1 - Sudden load change
Moment 2 - when instrument first detects effect of corrective action
D_M = Delay due to Measuring element
D_{cv} = " " " Controlled Valve
D_{sc} = " " " Side Capacities
P = a period made up of delays
2. Air Pressure due solely to controller's "automatic reset" or "droop correction" characteristic, if forced to follow curve above
"Control Point" (on all curves)
Control Pressure here
Greatest slope for greatest departure
Parallel
Note - Height and slope of air pressure change are exaggerated with reference to curve above
3. Air Pressure due to "proportional" AND "reset" characteristics
Moment of sudden load change
Slope here depends on relative weights of "proportional" and "reset" characteristics (here "proportional" weightier)
Slope upward here as "proportional" is constant
A
B
C
TEMPERATURE-TIME CURVE WHERE BASE LINE IS CONTROL-POINT TEMPERATURE
Area A = area B
C is Over-compensation
Continued cycling due to delays
4. Air pressure due to "proportional" and small "reset"
Temperature and pressure
5. Air pressure due to "derivative" controller characteristic as that obtained from the curve on "proportional" characteristic alone
Reference point on time scale:
A
B
6. "Derivative" AND "proportional"
A
C
Control point shift
7. "Derivative," "proportional" and "reset"
Ascending slope due to "reset"
Curve due to "proportional" alone
F.J.K.+M.F.B. 6.20.43

pointer away from the setting arm. The curve on the output pressure due to "reset" and "proportional" characteristics (Fig. 3) illustrates a typical difficulty one experiences with "reset"—namely, cycling of the process which either increases, remains constant, or decreases with time depending on how much too large the "reset rate" is. The extent of the pressure change due to "reset" is always small compared to the extent of the "proportional" corrective action in all usual cases. It is easy to see by the curve of Fig. 3 that any "reset" used on a control involving appreciable delays due to side capacities, etc., should be viewed with caution as slightly too much "reset" will cause bad cycling. "Reset" serves a useful purpose when lags and side capacities are small but load changes are large and the use of a "high sensitivity" ("narrow throttling range") gives essentially an on-off mode of control. Here, "medium sensitivity with reset" should and does hold a control point much better. A flow controller is a typical example of where a "reset rate" can be used to advantage.

In Fig. 4 it should be noted that the output pressure curve due to the "proportional" characteristic and a small "reset" will not go back to the original control point but will go up to a new control point which will force the temperature back to the original control point.

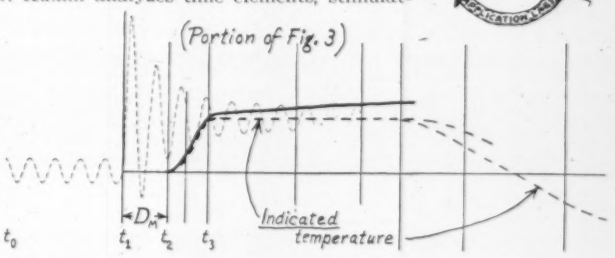
In Figs. 5 and 6, it should be noted that C is larger than B as the decrease in the line is also caused by the slug A given at the beginning. If the "derivative rate" is set right, the amount of C under the control point should be negligible. Otherwise if we set the "derivative rate" too high, we would get oscillations due to this cause. Thus we see that on long time lags, the "derivative" characteristic should help out a good deal.

From Fig. 7 we find that the amount of actual pressure change due to "reset" must be kept small in regard to the amount of actual pressure change caused by the "derivative" action if one is to keep away from cycling and bad control. From this, it appears that a practical way to adjust an instrument would be to adjust its "proportional" action, then its "derivative" action, and then add only enough "reset" to bring the indicating pointer to the setting arm in a reasonable amount of time. The "proportional" and "derivative" actions are both adjusted just under the point that cycling will take place. This will give the most economical adjustment for a given load as it will give the least area of the curve away from the control point. For other loads, the instrument must be set again for the most economical operation as the side capacities change in size. Consequently, on an operation where load changes occur, the "sensitivity," "reset," and "derivative" characteristics must be set low enough not to cause the instrument to cycle at any load expected. Setting the characteristics so that for a small load change each succeeding cycle is one-fourth the size of the preceding cycle is usually quite good.

Torrance, Calif.
May 5, 1943.

EMERSON L. KUMM
Instrument Engineer

[FINAL NOTE.—It is hoped that Mr. Kumm will elaborate this thought-provoking letter into a full-length article. His approach differs from that of Mr. Ziegler (see pages 394-397) who lumps together, under "process lag," all lags and delays, due to the application *and to the controller itself*, which delay the effect of a change of "output pressure" upon the "pen." Mr. Kumm analyzes time elements, stimulating readers to make deductions. Consider, for example, the behavior of the controller's measuring system: its pen does not even start to move until D_M minutes after the process temperature shoots up. (The controller, therefore, always acts too late.) It is interesting to try to deduce, from this pen behavior, the course of THE TRUE TEMPERATURE: in a complex multi-stage process (Mr. Kumm is with a famous chemical company) it *might* be the periodic oscillation we have drawn!—MFB]



Solving Control-valve Pressure-drop Problems

By H. C. McRAE
Research Engineer, The North American Mfg. Co., Cleveland, Ohio

AUTOMATIC CONTROL has been described as a circle of events, beginning and ending with the primary measuring element such as a thermocouple. A message is sent from the primary element to the "instrument" part, which in turn commands a motor which operates a final element such as a valve, switch or rheostat. A change in the flow of a fluid or electricity results, causing in turn, a change in heat flow which is detected as a change in temperature by the thermocouple.

This discussion will be limited to temperature control with the use of valves for controlling flow, although it will apply to any other application where an instrument commands a valve.

Depending upon the temperature variation permitted and such variables as door openings or changes in heating loads, there are available several types of instruments with various degrees of refinement to meet the various needs. This subject has been discussed rather thoroughly and need not be repeated here. It is the purpose of this article to illustrate the role of the valve. Just as there are various instruments, so there are valves with various degrees of refinement to be used with these instruments. Too often the proper instrument is chosen, only to have its accuracy defeated by incorrect choice of valve.

For two-, three-, or four-position control, the valve requirements are relatively simple. The proper fixed positions of the valve are found to give the desired flow rates. The valve chosen must have enough capacity to meet the largest flow and minimal leak to meet the smallest flow.

For throttling control, when the valve is moved to any or an infinite number of positions, it must have, in addition to adequate maximum capacity and minimum leak, a third property known as a good flow characteristic curve. A flow curve is shown in Fig. 1 which is simply the percent flow plotted against the percent opening of the valve. At the

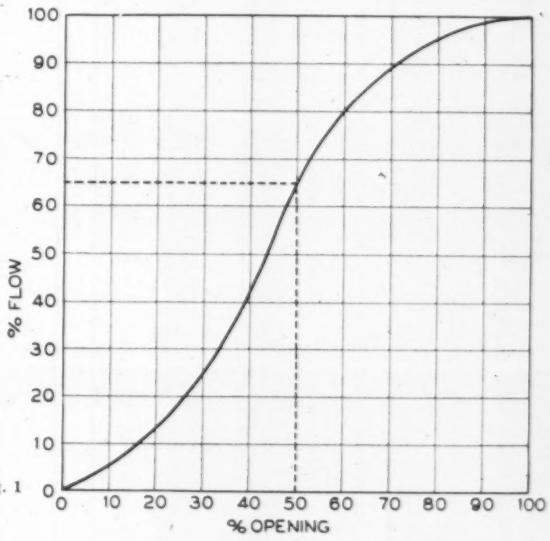


Fig. 1

half-open valve position (50%) the flow is 65% of that when the valve is full open.

In Fig. 2 are shown three different flow curves. Curve *A* is a common but undesirable curve. Between points *d* and *f* the curve is too steep, slight movement of the valve causing a greater change in flow than is expected by the instrument. This will in effect approach two-position control as the flow will continuously overshoot and undershoot the

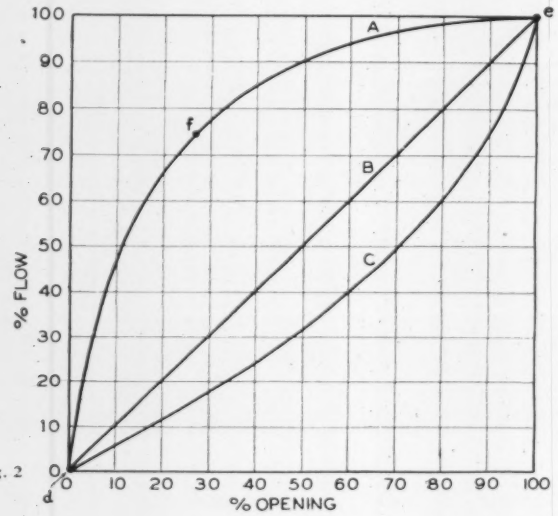


Fig. 2

correct value. From *f* to *e* the curve is too flat and the flow is likely to "drop" from the proper value. Curve *B*, a straight line, gives equal changes in flow over the whole range of the valve movement. This is the curve which most instrument companies strive for in practice.

In most combustion chambers, as the flow is increased the flue temperature rises, causing lower combustion effi-

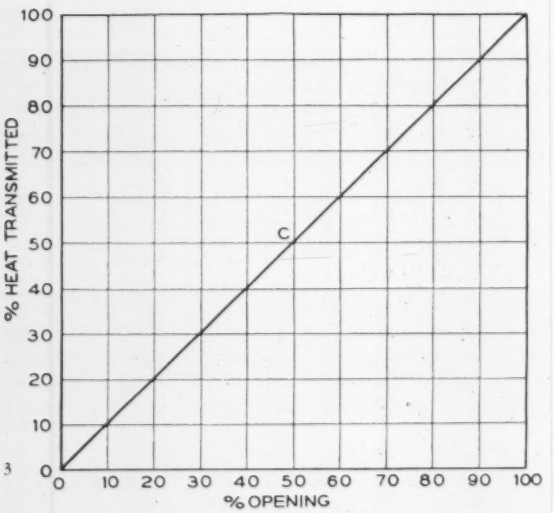


Fig. 3

ciency or less heat transfer for a given amount of fuel input. This means that at the larger valve openings it takes a greater increase in flow for a given valve movement to get the same increment in heat flow as obtained at a smaller valve opening. Such a condition is given as curve *C*. The same curve is shown again in Fig. 3 as a straight line because the percent heat transmitted is plotted instead of the percent flow. Curve *C*, then, is well suited for many applications. Ideally the instrument should control all things which cause heat to flow towards as away from the thermocouple, such as a change in load, but, of course, this is impossible. The best approach to true control is to control heat flow from the burners.

The answer to the valve problem seems simple enough: merely a matter of proper valve port construction to produce the proper curve. However, there is a "fly in the ointment." The flow curve is not determined solely by the valve itself. The remainder of the piping circuit, including the mixers, burners and piping, also affects the flow curve. An *inherent* valve flow curve is defined as the curve resulting with constant pressure drop across the valve. This is usually determined by testing a valve with constant pressure upstream and discharge directly to atmosphere. In valve practice the inherent flow curve is distorted because the pressure drop across the valve is not a constant. There are various methods available for determining the resultant flow curve from the inherent curve and the remainder of the piping circuit.* Fig. 4 shows three curves from the same valve in different circuits. The greater the pressure drop of the valve in the wide-open position or the smaller the valve is with respect to the rest of the circuit, the closer is the approach to the inherent curve where all of the pressure drop is across the valve. In practice it often is necessary to allow only a small drop across the valve to obtain

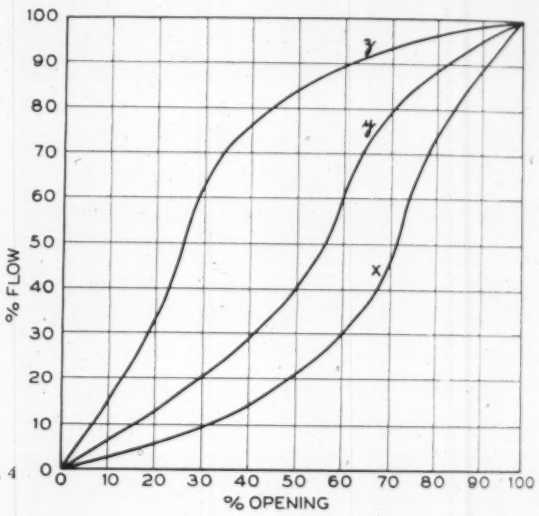


Fig. 4

sufficient capacity. This results in greater distortion and a poor curve such as shown at curve *z*. To repeat, the choice of a valve for throttling control is usually based upon a compromise between sufficient capacity (small drop) and the choice of a good flow curve. Since these requirements are obtained by opposite means, they are difficult to meet.

It is possible to build, for every circuit, a special valve which would give sufficient capacity and at the same time produce any desired flow curve, but, of course, this is not commercially practicable.

At this stage of development it was up to research to do the impossible. The problem was fourfold: to produce a valve which (1) would give any flow curve desired, (2) could be changed easily from one curve to another without removing the valve, (3) would operate independently of the circuit, and (4) would have no pressure drop in the full open position.

It has long been known that pressure regulators, unlike valves, operate in a manner which is independent of the piping circuit, that is to say, a pressure regulator controls a pressure at a given point in a circuit regardless of what

Concluded on page 4

*J. C. Peters, "Getting the Most Out of Automatic Control" Leeds and Northrup Co., 1941.

C. E. Mason, "Principles of Controlled Valve Reactions," Foxboro Co., 1930.

H. C. McRae, "Low-pressure Gas Flow Analyzing by a Resistance Theory," *Industrial Gas*, March 1941.

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For years the Type 5-101 Consolidated Portable Recording Oscillograph has been recognized as a high precision instrument offering the greatest completeness and simplicity of operation. Type 5-101A is the result of a thorough study of users' needs in meeting the most exacting requirements of modern test work. It retains all the features of the old model and provides the following important improvements.

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Automatic Operation. By single switch 2 foot records are recorded, numbered and titled.

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Self-recording, Semi-automatic Mechanized Electrometric Titrations

With Special Reference to Control of Gasoline Refining

By D. J. POMPEO, C. J. PENTHER and K. E. HALLIKAINEN
Shell Development Company, Emeryville, California

SUMMARY. An instrument is described that automatically records on a chart the mercaptan sulphur content of a treated gasoline in the range of zero to 0.001%. It is only necessary for an operator to place a measured amount of gasoline in the titrating vessel and to press a button to start the titration. Reproducibility is of the order of ± 2% of full-scale value with an absolute error of ± 5% in mercaptan content.

THE adoption by certain refineries of the solutizer process[1, 2] for the removal of mercaptan sulphur from gasoline requires an accurate measurement of the mercaptans present in the treated gasoline for proper control of the process. One of the control methods in use was the doctor test; but this was not entirely satisfactory because a sample of treated gasoline containing, for example, 0.0003% of mercaptan sulphur may occasionally be sour to the doctor test while one of 0.0004% on another sample may be sweet.

The potentiometric method described by Tamele and Ryland[3] for determination of mercaptans, as modified by Lykken and Tuemmler[4] to use the glass-silver electrode system for the determination of the end point has been satisfactorily applied for laboratory control of the solutizer process. However, the potentiometric method of analysis requires considerable manipulation by an experienced operator, including the plotting of a titration curve. For control of the plant this was not considered advisable and an automatic recording device was desired from which the mercaptan content could be obtained directly on a chart.

Tests showed that consistent results could be obtained if the titrations were made to a given voltage, selected for the particular type of gasoline; thus it was found unnecessary to plot a titration curve. This simplified the recording system because a vacuum tube electrometer with a relay for stopping the titration at the selected voltage, together with an automatic recording burette, would suffice.

Accordingly, an instrument was developed based on a mechanized potentiometric titration of mercaptan with alcoholic silver nitrate. This requires only that an operator introduce measured amounts of gasoline and conducting medium into the titrating vessel, place the vessel in the apparatus and press a button to start the titration. The percent mercaptan is read directly from a chart calibrated for the range 0 to 0.001% mercaptan. The reproducibility of the titration is of the order of ± 2% of full scale with an absolute error of ± 5% of the mercaptan sulphur, which is entirely satisfactory for the purpose. An analysis can be made in 2 to 12 minutes depending on the amount of mercaptan present in the sample.

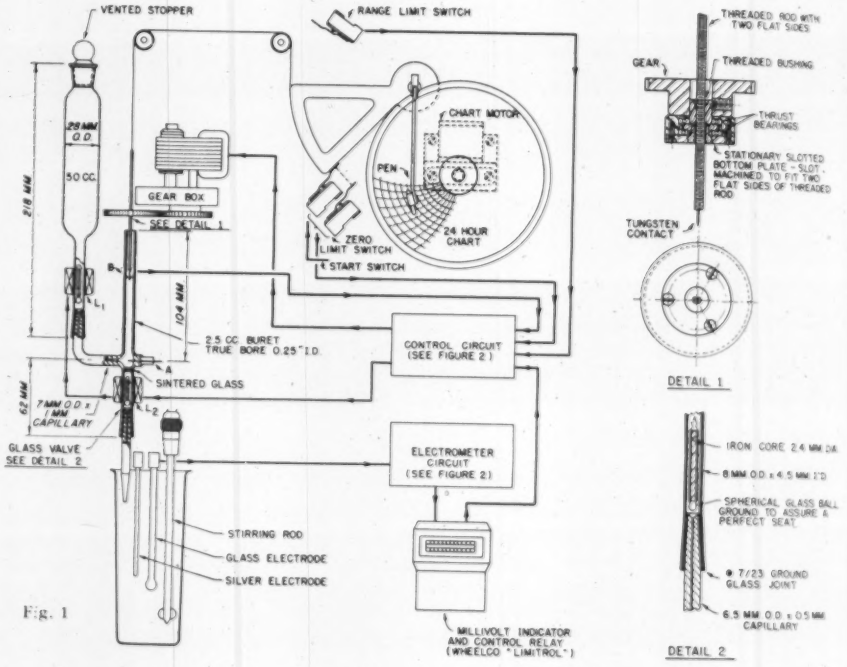


Fig. 1

The apparatus, shown schematically in Fig. 1, consists of four parts as follows:

(1) Automatic burette and glass valves

(2) Relay circuits for operating the automatic burette

(3) Electrometer for determining the glass-silver electrode potentials.

(4) The millivolt indicator and relay control circuit.

(1) *Automatic Burette.* This burette is a 3" length of 0.250" inside diameter precision-bore tubing. A magnetic valve connects the burette to a capillary tube which regulates the drop size. A side arm and another magnetic valve connect a 50-ml. reservoir to the burette.

The contact point *B* follows the liquid level as silver nitrate is added during the titration, and in so doing causes the pen arm to swing through an arc proportional to the silver nitrate used. The linkage between the moving contact *B* and the pen is a violin string.

The "drop" valve is actuated every 7½ seconds by a cam-operated switch driven by a small clock motor. The open time, together with the capillary diameter, determines the drop size. From five to eight drops per tenth milliliter have been found a satisfactory compromise between total time for a titration and sufficient time for equilibrium between drops. At the completion of a titration, the "drop" valve is automatically held closed while the refill valve is held open until the burette has filled and the recorder pen returned to zero.

The valve seats shown in Fig. 1 are ground with a brass tool having a tapered end of 90° included angle. The glass ball of each check valve is formed on the end of the glass tube by spinning this in a lathe and working the end with a carbon rod while heating with a small flame. For grinding the end of the check valve, a copper tool is used con-

(1) D. L. Yabroff & L. E. Border. The Solutizer Process for the Extraction of Mercaptans. *Refiner and Natural Gasoline Manufacturer*, Vol. 18, 1939, pages 171-176, 203.

(2) D. L. Yabroff & E. R. White. Action of Solutizers in Mercaptan Extraction. *Industrial & Engineering Chemistry*, Vol. 32, 1940, pages 950-953.

(3) M. W. Tamele & Lloyd B. Ryland. Potentiometric Determination of Mercaptans. *Industrial & Engineering Chemistry, Analytical Edition*, Vol. 8, 1936, pages 16-19.

(4) L. Lykken & F. D. Tuemmler. Glass Electrode as a Reference Electrode in Electrometric Titrations. *Industrial & Engineering Chemistry, Analytical Edition*, Vol. 14, 1942, pages 67-69.

aining a hemispherical depression ade by pressing into the copper a 125" diameter steel ball. The first ball discarded and the final seat is made ith a new ball. In each case a separate ol should be used for each grit of carorundum flour from number 302 to 03½. The final seat between matched lass pairs is made with rouge. There hould be a line of contact between the emispherical end and the 90° seat. he valves should not leak when tested ith alcohol.

(2) *Relay Circuits.* The contact *B* is aused to follow the silver nitrate eniscus by a system consisting of an lectronic relay (5-microamp. contact urrent), a single-make contact prinary relay and a multi-contact double-hrow secondary relay. A full-range witch and a zero-limit switch are also rovided.

(3) *Electrometer.* The potential easuring device can be any standard type of vacuum tube electrometer suitable for measuring glass electrode potential, capable of operating a millivolt type of indicator. In this application the circuit described by Penther and Rolfson,[5] simplified as shown in Fig. 2, has been used to good advantage.

(4) *Indicator and Relay Circuit.* A Wheelco "Limitrol" was adapted as a combined indicating meter and master relay. The scale was calibrated from +200 mv. to zero to −300 mv. This instrument is provided with an adjustable pointer that can be set at any position on the scale, thus determining the point at which the relay operates. This setting is at the value chosen as the titration end-point, usually about −250 mv.

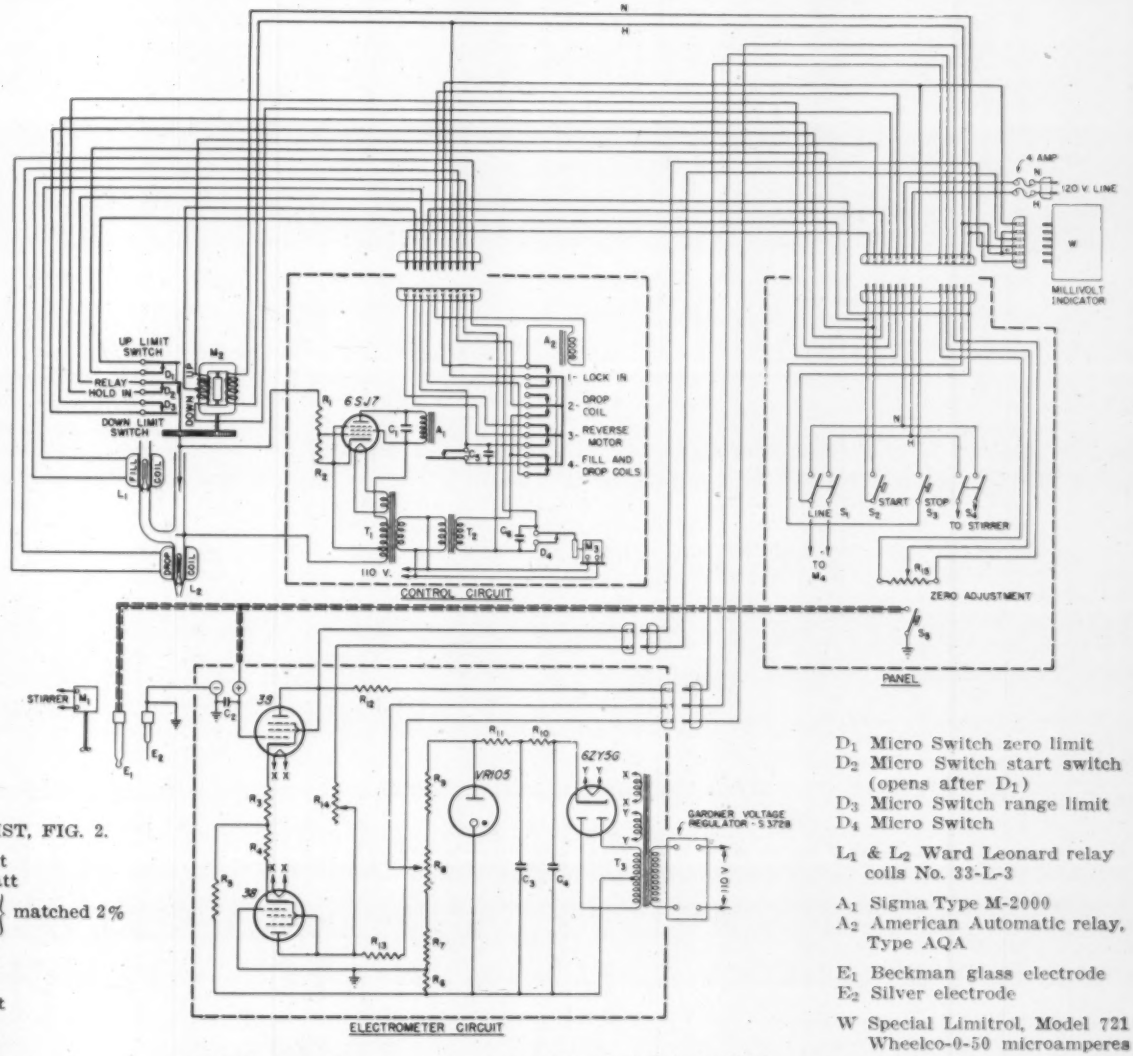
Safety Features. In designing this instrument, special consideration was given to making it explosion-proof so that it could be used in hazardous areas in a refinery. To this end the relays and other parts having make-and-break contacts were housed within the cabinet which was made as nearly air-tight as practicable. Air from a compressed air line, at approx. 1" water pressure, is applied to the cabinet through a simple reduction valve. A water manometer serves as a pressure indicator as well as a safety valve protecting the cabinet from excessive pressure. Since a positive pressure is always maintained in the cabinet there is little chance of an explosive mixture entering and the explosion hazard is practically eliminated.

A photograph of the instrument is shown in Fig. 3. The potentiometric stand and assembly is similar to that described by Lykken and Rolfson.[6]

Continued on page 449

(5) C. J. Penther & F. B. Rolfson. Dual Alternating Current Titrometer. *Industrial & Engineering Chemistry, Analytical Edition*, Vol. 15, 1943, pages 337-340.

(6) L. Lykken & F. B. Rolfson. Potentiometric Titration Stand Assembly. *Industrial & Engineering Chemistry, Analytical Edition*, Vol. 13, 1941, pages 653-655.



PARTS LIST, FIG. 2.

R_1 100M 1 watt
R_2 1 Meg 1 watt
R_3 1.0M 1 watt } matched 2%
R_4 1.0M 1 watt }
R_5 50M 1 watt
R_6 20M 10 watt
R_7 5M 10 watt
R_8 10M 4½ watt
R_9 3M 10 watt
R_{10} 3M 10 watt
R_{11} 3M 10 watt
R_{12} 5M 1 watt } matched 2%
R_{13} 5M 1 watt }
R_{14} 5M 4½ watt
R_{15} 600 4½ watt

C_1 2 mfd 600-volt
C_2 0.001 mfd Sangamo 1000-volt mica low loss
C_3 4 mfd 450-volt
C_4 4 mfd 450-volt
C_5 0.1 mfd 600-volt
C_6 0.1 mfd 600-volt

M_1 Eastern Engineering stirring motor
M_2 Barber-Colman motor, Cat. No. OYA$_3$ 430
M_3 Warren Telechron Type B-2 motor 4 rpm.
M_4 Warren Telechron IM-2 24 hr. chart movement with B-11 mtr. & slip friction drive

T_1 Gardner Transformer, Type S3069
T_2 6 Volt Transformer
T_3 Gardner Transformer, Type S3690

D_1 Micro Switch zero limit
D_2 Micro Switch start switch (opens after D_1)
D_3 Micro Switch range limit
D_4 Micro Switch

L_1 & L_2 Ward Leonard relay coils No. 33-L-3

A_1 Sigma Type M-2000
A_2 American Automatic relay, Type AQA

E_1 Beckman glass electrode
E_2 Silver electrode

W Special Limitrol, Model 721 Wheelco-0-50 microamperes

S_1 Single-throw double-pole switch
S_2 Single-pole push switch
S_3 Single-pole push switch
S_4 Single-throw double-pole switch
S_5 Single-pole switch, low loss, for grounding grid while adjusting zero

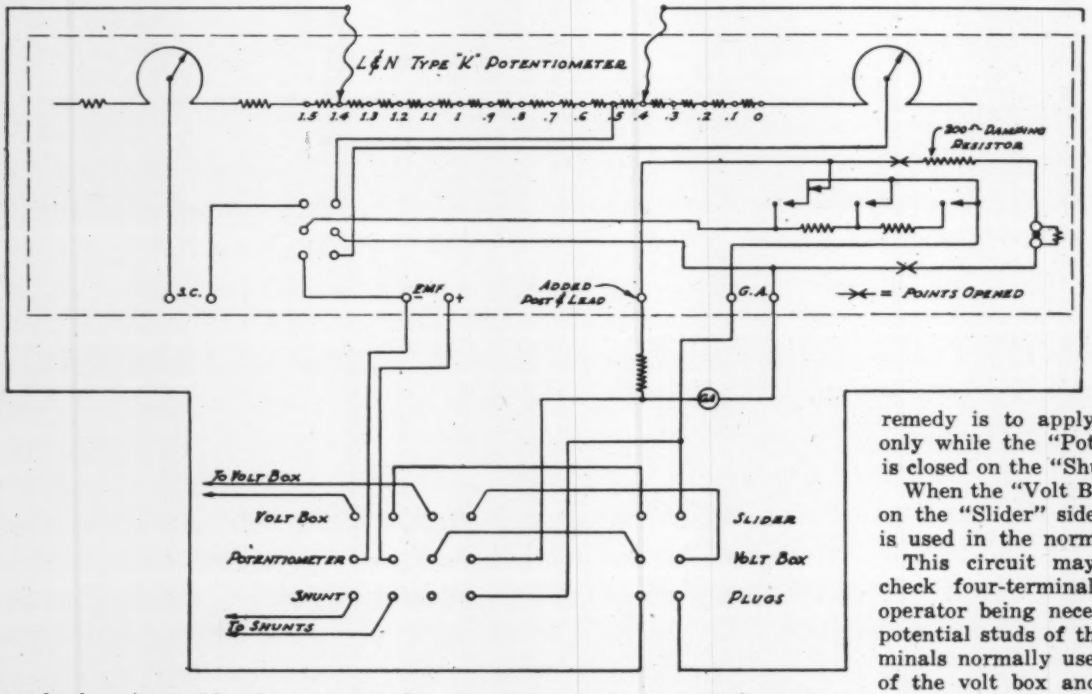
Testing Wattmeters With One Potentiometer

By MORRIS UNDERWOOD
Laboratory Technician, Indianapolis Power & Light Co., Indianapolis, Indiana.

IN making tests on wattmeters, it is necessary to keep the applied potential at a certain value while the current is being measured. This may be accomplished by the use of two potentiometers—one used to set and hold the applied potential and the other to measure the potential drop across a standard resistor. If only one normal potentiometer is used, the main dial and slider need to be reset for each reading.

The studs on the main dial of the Leeds & Northrup Type K Potentiometer are drilled for the insertion of two small plugs on cords originally supplied with the potentiometer. The fixed potential thus obtained can be opposed to the potential drop on the low side of the volt box and the potential regulated to a certain definite value. Then, after operating only one switch, the current may be measured in the usual manner. It is possible to check the potential at the wattmeter without disturbing the setting of the potentiometer dial and slider.

The diagram herewith shows the circuit used to accomplish the desired result.



The internal damping resistance had to be removed since it would connect the galvanometer across a portion of the battery circuit if the standard cell were applied while the "Potentiometer" switch was closed to the "Volt Box" side for a potential check. The damping resistance was restored externally by adding a new terminal for it. Even with the damping circuit open, an attempt to apply the standard cell would result in an error depending on the potential difference between the normal standard cell tap (to 0.5-volt tap) and the position of the lower plug. This, however, would be so large an error as to cause the operator to check the connections and locate the trouble. The remedy is to apply the standard cell only while the "Potentiometer" switch is closed on the "Shunt" side.

When the "Volt Box" switch is closed on the "Slider" side the potentiometer is used in the normal manner.

This circuit may also be used to check four-terminal shunts, only one operator being necessary. Connect the potential studs of the shunt to the terminals normally used for the low side of the volt box and use the 0.16-volt range of the potentiometer. Adjust the current until the millivolt drop of the shunt is at the predetermined value then measure the current using a standard resistor.

The circuit described above has been used in the Meter & Relay Department Laboratory for several years with highly satisfactory results.

We wish to thank the Leeds & Northrup Company for their suggestions for the development of this circuit.

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Both instruments—Type 224 (3-inch) and the new Type 241 (5-inch) set *new standards* for commercial-grade oscillographs. Wide-band Y-axis amplifiers permit study of signals of frequencies far beyond the range of usual instruments. Both have a comparably wide-band square and sinusoidal wave response. Both permit a wide choice of panel connections for extreme flexibility in applying signals to the cathode-ray tube. Both are ruggedly housed and supplied with removable front cover for added protection in transit or when not in actual use.

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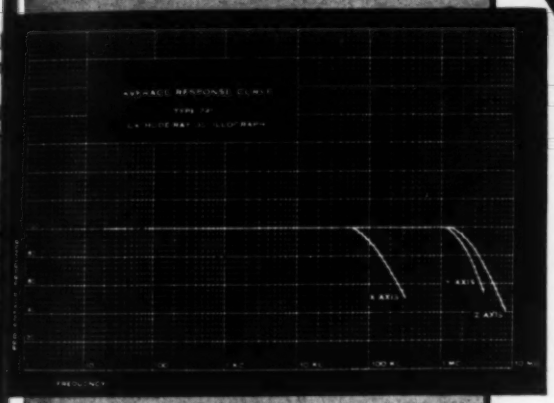

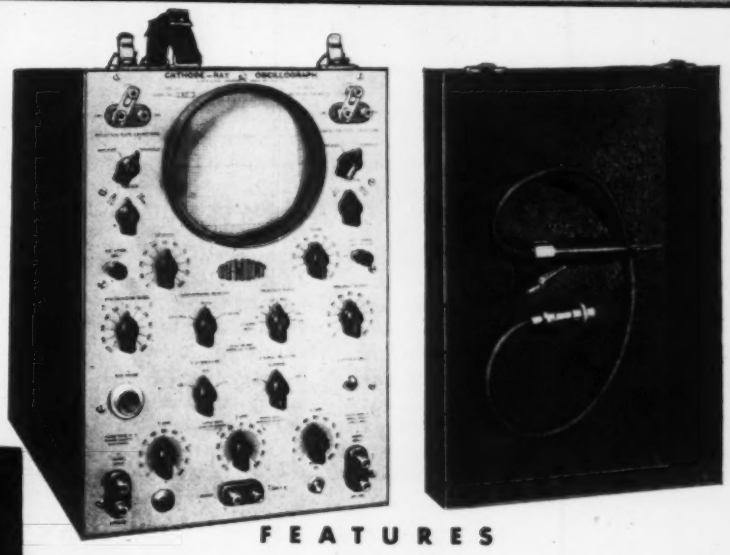

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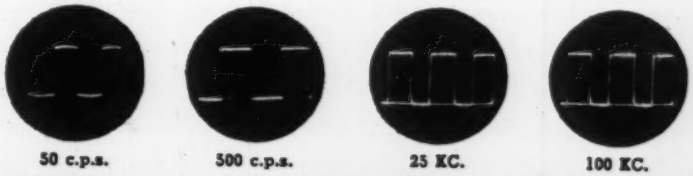

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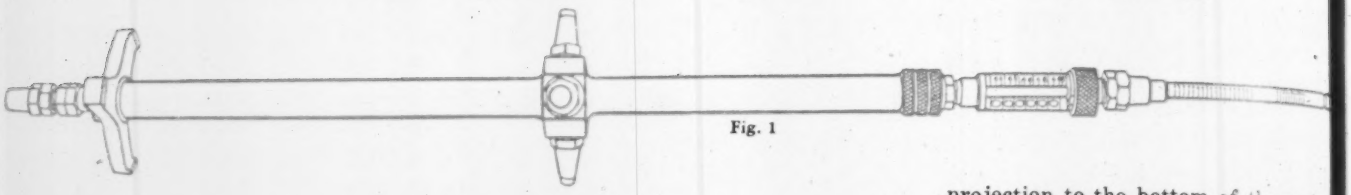

Fig. 1

By RAYMOND J. FITNESS

Manager in Charge of Manufacturing, Willys-Overland Motors, Toledo, Ohio

TO date, the shell gage described herein has saved Willys-Overland Motors more than a million and a half pounds of steel and over fifteen thousand man-hours in the production of 155mm. shells. After this gage went into use at the Willys plant, only 200 shells out of a production of one million were rejected by the Army. If the previous rate of rejection had been continued, nearly 3,500 per million would have failed to meet Army requirements. It was no surprise to us that this gage enjoyed nation-wide acclaim last month when its co-designers, Frank Speke and Clarence Reynolds, received one of the four major prizes presented annually by American Design Award Committee.*

In evaluating the worth of this gage, it is necessary to sketch briefly the manufacturing problem solved by the Speke and Reynolds invention.

Willys-Overland was the first company to undertake the manufacture of the 155mm. shell on a mass production basis using the forge method of production. New methods had to be developed. The most difficult problem was that of the shell cavity, which controls all the dimensions of the shell. Despite the use of the most accurate forging processes, it is not possible to hold the forged cavity of the shell to close tolerances, Therefore it was difficult to maintain a finished *weight* of the shell which would pass rigid weight inspection. Necessity for small weight tolerance stems from requirements for absolute accuracy in firing. When captured German officers in Tunisia spoke with awe of our artillery's accuracy, they were unwittingly complimenting the strictness of the Army Ordnance weight inspection.

Charged with the responsibility of solving this weight problem were the chief inspectors of the 155mm. shell manufacturing departments, Frank Speke and Clarence Reynolds. They worked on the problem for three months and, after weeks of experimentation and mathematical computations, they had ready for use a cavity gage which indicates variations in the dimensions of the forged shell cavity. The actual work on building the first gage was done in Speke's home workshop during evenings.

The shell cavity (see Fig. 2) consists of a straight portion which blends into a taper portion, both of which affect the ultimate weight of the finished shell. The difficulty of devising an instrument to measure such a cavity in one quick operation is apparent.

The gage developed by Speke and Reynolds consists of a three-point bearing in the taper portion, the diameter of which is measured by a sliding rod projection to the bottom of the cavity. The straight portion of the cavity is measured by three expanding pins operated by a taper cone which is concentric with the depth rod of the taper portion. The taper of the cone is such that it has the correct proportion in weight between the straight and taper portions of the cavity. The tube operating the cone, at its outer end, carries a head which is marked off in divisions of weight.

The operating rod which checks the taper portion carries the index line. By this means the weight of the taper and of the straight portion are compounded into the correct dimensional weight of the entire cavity. In simple terms, the gage measures the plus or minus weight of the shell cavity.

In use on the machine line as the shell forging comes from the forge division, the weight divisions of the gage are painted with dots of six different colors. The operator, in sliding the gage into the cavity, can tell at a glance which color is indicated. The shell is then marked with the appropriate color by a daub of paint. This gives the operator of the nosing press the information he needs to bring the shell to the desired finished weight within the close tolerances required by government inspection.

The gage is designed and built in such a manner that it will take hard usage. It has simple adjustments for wear. It is light enough to be used rapidly on the production line. At this writing it is being used by nine other manufacturers of medium artillery shells.

*Other recipients of the $1000 awards: Igor Sikorsky, for his successful helicopter; Edwin Goldfield, who developed the mobile x-ray unit now used in the field by the Army, and William Gibbs, who designed the Liberty ships.

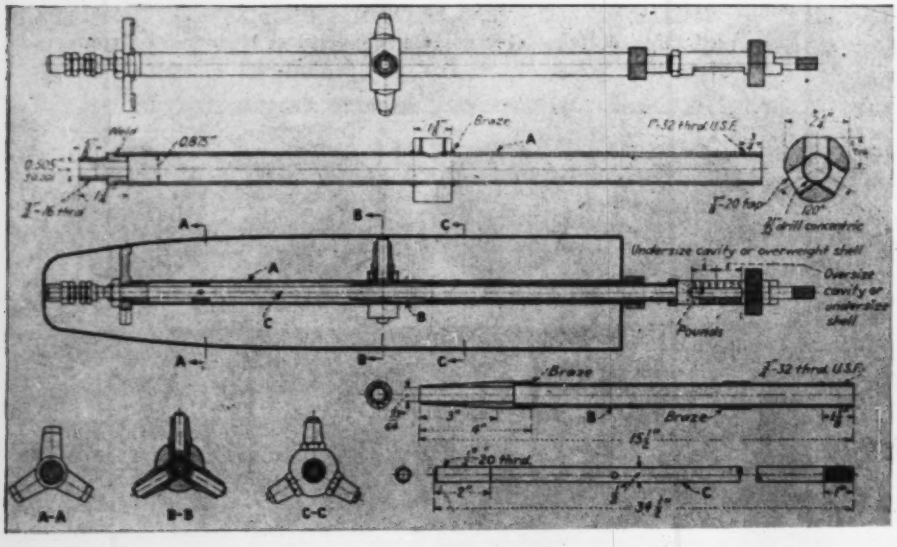

Fig. 2. Details of the shell cavity gage.

Fig. 3. Speke (left) and Reynolds (center).

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DESIGN, ENGINEERING & PRODUCTION
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ELECTRON TUBES

Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER
Managing Editor, *Power Plant Engineering*, Chicago, Ill.

CHAPTER IV

THE TRIODE AS AN AMPLIFIER

The two-electrode tube considered in the preceding chapter, though extremely useful as a rectifier, is quite limited in its functions in comparison with other types of tubes now to be considered. The first, and fundamentally the most important of these other types, is the three-electrode tube or triode. This tube differs from the two-electrode tube only in that a third element, called a grid, is interposed between the cathode and the plate as shown in Fig. 17. As its name indicates, the grid usually takes the form of a fine wire mesh or screen and is so placed that the electrons in their flight from the cathode to the plate are compelled to pass through the openings in the grid. The openings in the grid are large compared to the size of the wires so the grid permits of a practically unobstructed flight of the electrons.

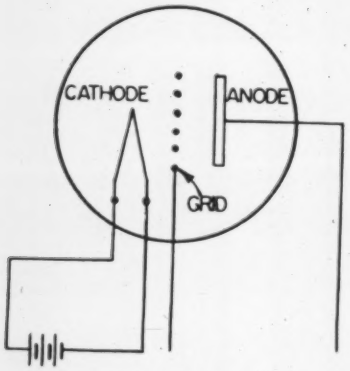

Fig. 17. Diagram of the three-electrode electron tube or triode. The structure is essentially the same as that of the diode, except that a fine wire mesh or grid is mounted between the cathode and the anode. The electrons on their way from the cathode to the anode have to pass through the openings of this grid.

The purpose of this grid is to control the passage of the electrons, i. e., the plate current. Like the plate, it is provided with a separate external terminal so that it may be charged electrically. Normally when no potential is applied to the grid, the tube functions as a diode.

If, however, by connecting it to a separate battery or other source of potential, the grid is made positive or negative with respect to the cathode, the plate current will increase or decrease. When the grid is given a positive potential, the plate current increases; when it is made negative, the plate current decreases, indeed, it may drop to zero. Furthermore, if the change in plate current with applied grid voltage is carefully measured, it will be found that an extremely small variation in grid voltage produces relatively large changes in plate current. Furthermore, the change in plate current may be made directly proportional to the change in grid voltage. This control action permits the tube to be used as a relay or as an amplifier. The amount of change in grid potential required to effect a certain change in plate current is much less than would be required to effect a similar change in plate current by direct variation of the plate voltage.

To explain this curious property of the grid in controlling the plate current, let us return to the two-electrode tube for a moment and consider the effect of varying the distance between the cathode and plate as shown in Fig. 18.

From elementary electrical theory we know that the force between two electric charges varies inversely as the square of the distance between the charges. (Coulomb showed experimentally that if two electric charges of magnitude Q_1 and Q_2 respectively are placed r cm. apart in air, they repel each other with a force of $Q_1\ Q_2/r^2$ dynes.) In the electron tube, therefore, it is possible to increase the plate current by decreasing the distance between the cathode and the plate, because if the plate is brought closer to the cathode, the positive force acting on the electrons in the space immediately surrounding the cathode is increased. Or, considering it in a different way, if the cathode and the plate are brought closer together, a smaller plate potential is required to maintain the same plate current.

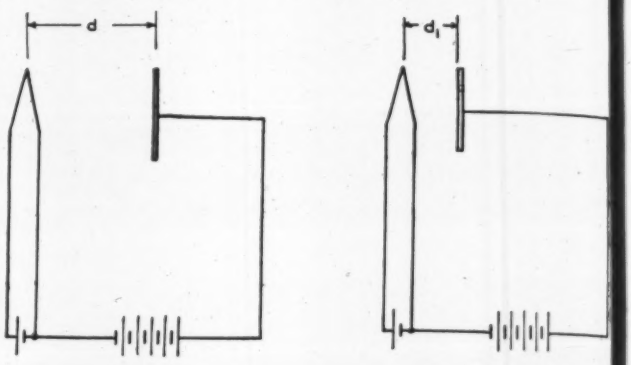

Fig. 18. In the diode, with a fixed plate potential, it is possible to vary the plate current by varying the distance between the cathode and anode. When the distance d is decreased to d_1 the plate current is increased.

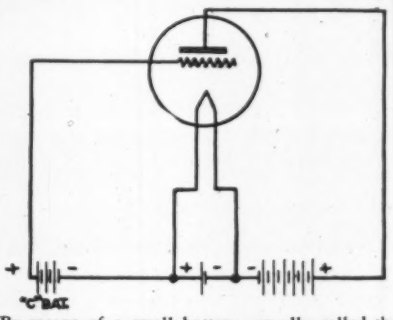

Fig. 19. By means of a small battery, usually called the "C" battery or (more properly) the grid bias battery, the grid can be maintained at any required negative potential.

Suppose, however, that instead of moving the plate closer to the cathode, a grid is placed between the cathode and the plate and a slight positive charge is imparted to this grid by connecting it to the positive terminal of another battery: battery C in Fig. 19. It is obvious that this positively charged grid will act very much like an additional plate and that it will aid the plate in drawing electrons away from the cathode. Also, since the grid is closer to the cathode than is the plate, a smaller positive charge is needed to exert a given attraction than would be necessary if an additional positive charge were applied to the plate. (In

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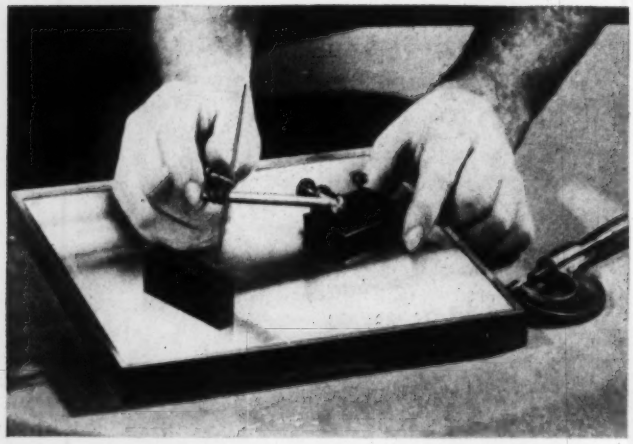

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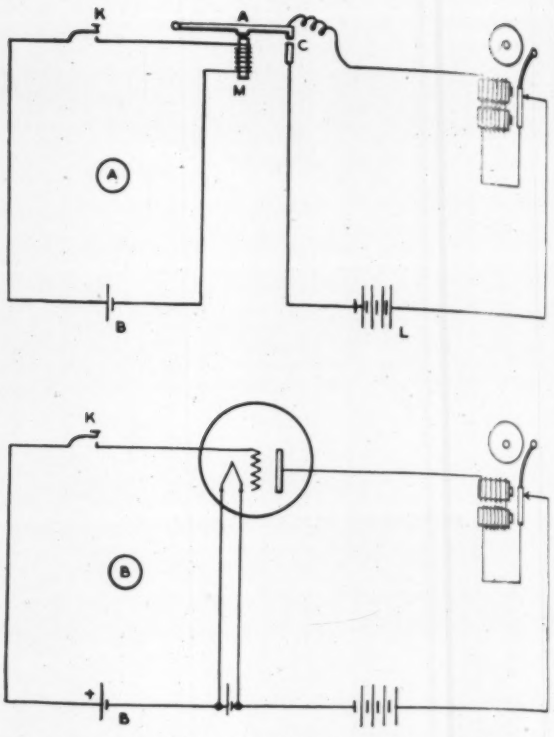


Fig. 20. Analogy between magnetic relay and three-electrode tube. In diagram A, closure of the key K energizes magnet M causing it to attract armature A, thus closing contact C. This allows current from the local battery L to energize the bell. In diagram B, the electron tube takes the place of the magnetic relay. With the grid neutral the plate current is insufficient to energize the bell, but when the grid is given a positive charge by closing the key K, the plate current increases and the bell is energized.

practice, the grid usually is *much* closer to the cathode than is the plate.)

If instead of charging the grid positively, it is given a negative charge by connecting it to the negative terminal of battery *C*, the electrons emitted by the cathode will be repelled by the negative field around the grid and a smaller proportion of them will reach the plate. If the negative charge on the grid is sufficiently great the effect of the positive charge on the plate may be completely neutralized, reducing the plate current to zero. In practice, and for reasons to be explained later, the grid is usually maintained at a negative potential in this manner.

The three-electrode tube, therefore, in addition to having the rectifying property of the diode, also serves as a relay or, more correctly, as an amplifier. In Fig. 20 the relation between an ordinary magnetic relay and the three-electrode tube is shown. When electromagnet *M* (Fig. 20A) is energized by the comparatively weak current from battery *B*, armature *A* is pulled downward. This movement closes contacts *C*, permitting current from the local battery *L* to energize the electric bell. In this way a large bell requiring a

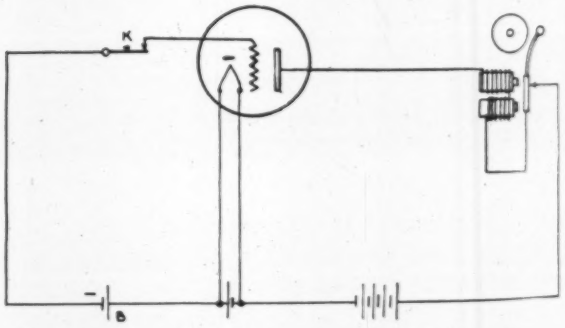


Fig. 21. In this circuit the grid is normally maintained at a sufficiently high value to prevent any plate current from flowing. When the key K is opened, the grid charge drops to zero and its restraining influence on the plate current is removed, causing plate current to flow.

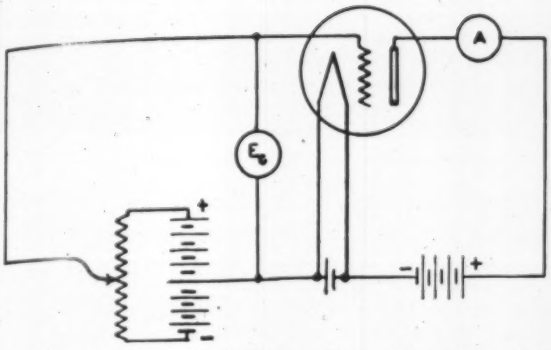


Fig. 22. Triode circuit in which the grid potential can be varied uniformly between certain negative and positive limits by means of the battery and voltage-dividing resistor (sometimes called potentiometer) in the grid circuit.

elatively strong current can be operated from a distant ource by a current too weak to operate the bell directly.

In the electron tube analogy shown in Fig. 20B the action s similar. Here, the electromagnet with its associated mov- ng armature and contacts are replaced by a single three- lectrode tube. The grid corresponds to the electromagnet. With key *K* open, as shown, the grid is at zero potential nd the plate current, it can be assumed, is insufficient to ring the bell. When the key is closed, the grid is charged positively by battery *B*, causing the plate current to in- crease and ring the bell.

A more practical way of operating the electron tube cir- cuit would be to connect it as shown in Fig. 21. In this case, he key is normally closed and the battery so arranged as o maintain the grid at a negative potential. The negative harge on the grid is such as to neutralize the effect of the late potential and normally no plate current flows. When ey *K* is opened, however, the grid potential drops to zero; ts restraining influence on the plate potential is removed; nd the plate current instantly rises to a maximum, oper- ting the bell. It is to be noted that no energy is consumed n maintaining the grid at a negative potential.

This is an exceedingly simple application of the triode nd does not begin to do justice to its full capabilities as an mplifier, for in this case no use is made of its ability to ary the plate current in exact accordance with the varia- ion in grid potential. So, let us now consider the circuit in ig. 22. Here is shown a triode with an ammeter (*A*) in its

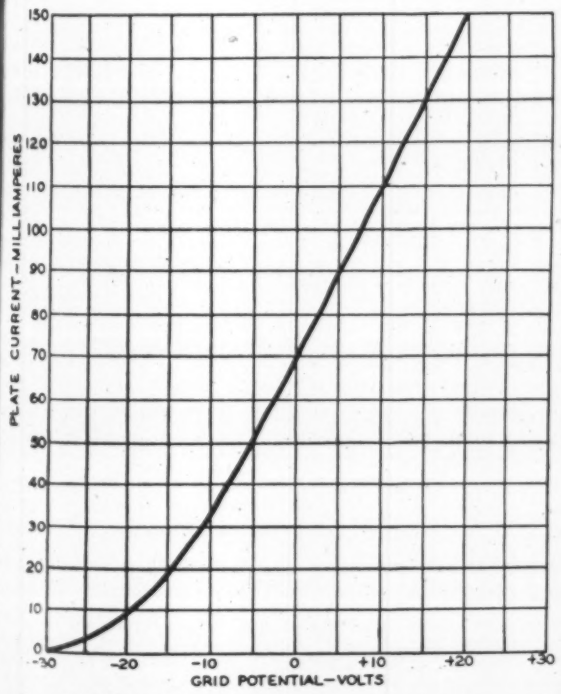
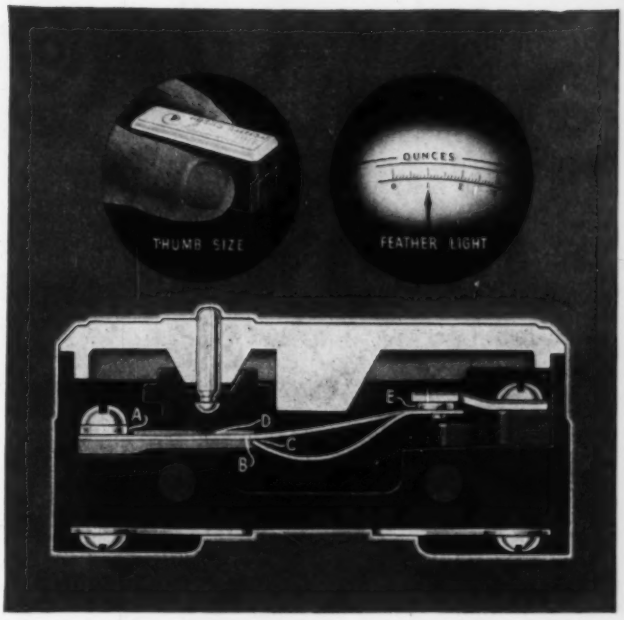


Fig. 23. Plate-current—grid-potential characteristic of a typical medium size triode for a plate voltage of approximately 700 volts.



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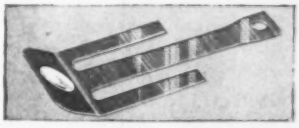

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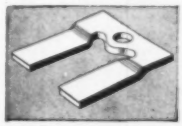

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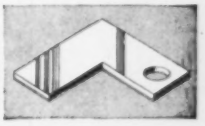

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plate circuit to measure the plate current, and with a b tery and potentiometer in the grid circuit so that the g potential (with respect to the cathode) can be varied b tween certain positive and negative limits. The zero-cen voltmeter E_G measures the grid potential. The plate pot tial, of course, is fixed by the potential of the plate batte

As the potentiometer slider is moved along the resista from the negative end to the positive end, the grid potent varies gradually from a negative value to a positive val This, by virtue of the controlling action of the grid pot tial upon the plate current, causes the latter to vary, a if we plot this variation in plate current against the g potential a curve such as shown in Fig. 23 is obtained. a grid potential of 30 volts negative, no plate current flo As the grid is made less negative, however, its restrainin influence over the electrons emitted by the cathode is dimi ished and the plate current rises. At –20 volts grid pote tial, the plate current is about 9 milliamperes. At –10 g volts, it is 33 milliamperes. And so, for zero grid volts, – and +20 the corresponding plate currents are 70, 110 a 150 milliamperes respectively. In other words, a swing grid potential from –30 to +20 results in a swing in pla current from zero to 150 milliamperes.

So far we have considered only the variation of cu rent in the plate circuit. This variation in plate curren however, can also cause a variation in voltage and this important. Suppose that in addition to the ammeter in t plate circuit we also connect a resistance R, as shown Fig. 24. From Ohm's law, we know that when a current

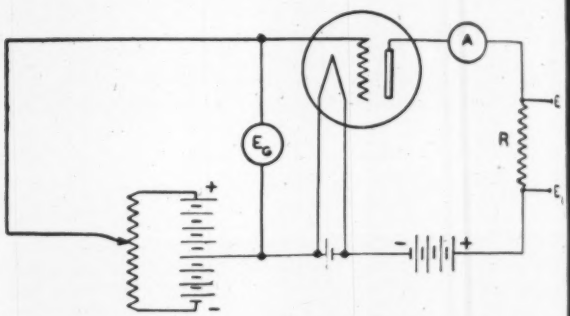

Fig. 24. When a resistance R is introduced into the plate circuit, the varying plate current through this resistance creates a varying voltage across the terminals E E_1 which is an amplified version of the exciting grid potential.

sent through a resistance, a voltage appears across th terminals of this resistance. This is known as the voltag drop and its value is given by the well-known relation

$$RI = E$$

in which R is the resistance in ohms, I the current in am peres and E the potential in volts.

As a consequence of this relation, the variation in plat current through resistance R, in Fig. 24, causes a voltag variation across the resistance that is a magnified versio of the variation in grid voltage. In other words, the tub in this case *acts as a voltage amplifier.*

The measure of the amplification of which a tube i capable is known as its amplification factor. This is usuall designated by the Greek letter μ (mu) and is an extremel important tube characteristic. This factor will be discusse in greater detail later on but for the present it will be suf ficient to understand that a tube can be made to functio in this manner.

The operation of the electron tube as an amplifier ca be represented, graphically, by plotting the plate curren wave at right angles to the grid potential wave in the man

*Assuming that the circuit has no inductance and unlimited series capacitance, this is merely the expression for dynami equilibrium in the circuit. Viewed from the standpoint of dynamic the statement asserts that the counter voltage RI must equal th driving electromotive force E. Resistance R is the factor which, multiplied by the current, establishes the expression for the resis tive counter-voltage. Resistance is the property of an electric cir cuit which directly opposes the movement of electricity and causes a non-reversible transformation of electrical energy into heat.

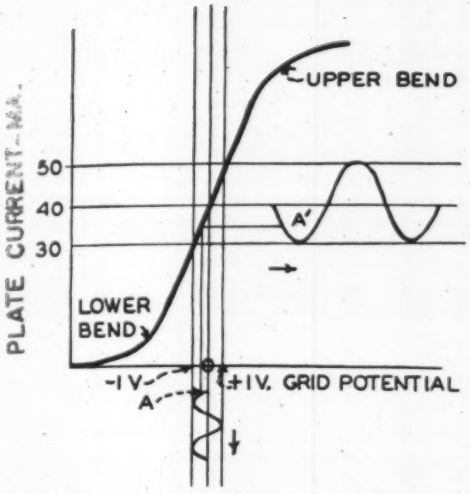

Fig. 25. Graphic representation of the amplifying property of the triode.

ner shown in Fig. 25. This diagram, it will be noted, makes use of the plate current-grid voltage characteristic. If any point on the *lower* wave, such as *A*, is projected *up* to the curve and then projected at right angles, a point *A* will be obtained on the plate current wave. Thus, each point on the grid potential wave can be translated to a corresponding point on the plate current wave.

In the example shown in Fig. 25 a small alternating potential of 1 volt is applied to the grid and by the method just outlined the corresponding plate current wave is obtained. In this particular example, when the grid is at zero potential, a plate current of 40 milliamperes flows in the plate circuit. When the grid potential becomes 1 volt negative, the plate current drops to 30 milliamperes. Similarly, with a grid potential of 1 volt positive, the plate current becomes 50 milliamperes. Thus the application of a 1-volt alternating potential to the grid results in a current in the plate circuit which varies periodically between 30 and 50 milliamperes.

It should be noted that this plate current is not an alternating current, but an "undulating" direct current. It varies in its intensity but not in direction; it is a periodically varying direct current, equivalent to an alternating current superimposed upon a pure direct current of 40 milliamperes. The wave shape of this superimposed alternating current is an exact but amplified reproduction of the voltage wave applied to the grid.

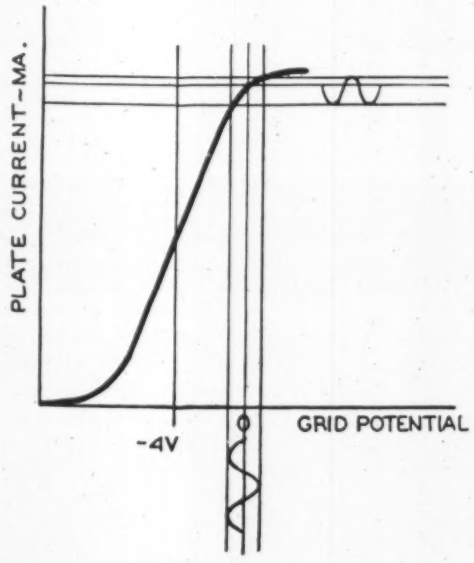

Fig. 26. When the operating point occurs at the bend of the curve, distortion results.

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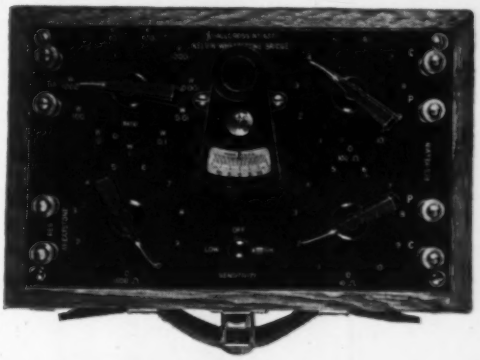

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From an inspection of this diagram, it might be thought a coincidence that the zero grid voltage point falls almost exactly in the center of the straight portion of the slope of the curve, for had it occurred at either the lower or upper bends of the curve, this exact wave-shape relation would not have held true. Consider Fig. 26. Here is shown the same curve as in Fig. 25 but in this instance (for the sake of illustration) the zero grid operating point falls on the upper bend of the curve and the linear relationship between grid potential and plate current no longer holds. In this case the

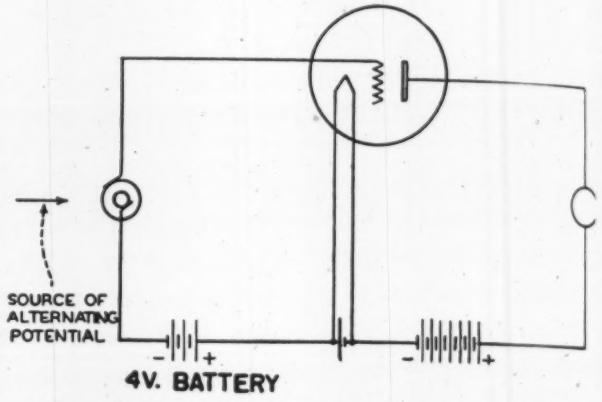


Fig. 27. Diagram showing the use of a grid bias battery in adjusting the operating point of the tube.

plate current is distorted, the lower loop being larger than the upper loop. Also, the variation in plate current is much smaller.

It is quite evident, then, that if the tube is to function properly as an amplifier, the middle portion of the slope of the curve must be used. Of course, it must be understood that such a curve as is shown in these diagrams is the characteristic for a definite plate voltage. If a different plate

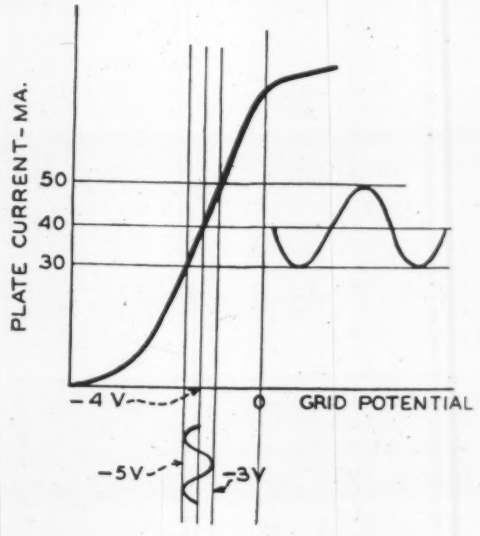


Fig. 28. In this instance a 4-volt battery is used to shift the operating point to the proper place on the curve for undistorted amplification.

voltage is selected a different curve will result. It might be possible to select a plate voltage such that the zero grid potential would fall exactly in the middle of the straight portion of the slope; but in practice it is simpler and more expedient to vary the operating point by adjusting the negative potential of the grid by means of a "grid bias battery."

In Fig. 26, for example, to obtain undistorted amplification, it is necessary that the impressed alternating potential operate around a point which is, say, 4 volts negative with

respect to the cathode for this line intersects the middle point of the curve as shown. So a small 4-volt battery (or generator) is connected in the grid circuit as shown in Fig. 27 with its negative terminal tied to the grid. The small alternating current generator shown is assumed to furnish the exciting potential.

Thus the 1-v. alternating exciting potential is now superimposed upon the 4-v. negative battery potential and it will oscillate between –3 and –5 volts as shown in Fig. 28.

In this way, by adjusting the "bias" voltage of the grid, as it is called, a tube can be made to function as an amplifier or for other purposes as desired. If the operating point is set towards the bottom or top of the curve there will be distortion in the output wave. For some purposes such distortion is desirable and necessary but for undistorted amplification only the straight portion of the characteristic can be used as this provides the linear relationship demanded.

In considering this amplifying characteristic of the three-electrode tube, attention is directed to the *slope* of the curve. The amount of amplification, it will be noted, is a function of the steepness of the slope of the curve: the steeper the slope, the greater the amplification. The character of the slope of the curve is dependent upon the spacing and the constructional features of the tube elements. It is a factor which the tube designer has to keep in mind.

In this chapter, only the simplest aspects of the triode's operation have been considered but these also are its most fundamental aspects. The diode, it will be recalled, was stated to be, fundamentally, a rectifier. To the extent that the grid can be ignored, the triode also is a rectifier, but when the grid is considered the triode becomes, fundamentally, an amplifier. Strange as it may seem, these are really the only fundamental properties of all electron tubes—all other characteristics and functions can be derived from these simple properties. If this is clearly understood one should have less trouble in understanding the more involved characteristics and applications to be considered later.

Before concluding this chapter, a word about the history of the triode. The triode was invented by Dr. Lee De Forest in 1907 as a result of his experiments with the diode which was invented by John A. Fleming. Fleming in 1905 first recognized the rectifying principle of the two-electrode tube and obtained a patent on the use of the diode, as a detector of high-frequency electrical oscillations. This patent became one of the fundamental patents in electron tube development.

Fleming worked in England. In America, Lee De Forest also was engaged in the development of a system of wireless telegraphy and in the course of his work made use of the Fleming valve, as it was then known. It was the best detector of wireless signals that had been developed up to that time but its functions, naturally, were limited to those of a rectifier. It was during these experiments that De Forest conceived the idea of introducing a third element into the tube. A simple thing, and yet perhaps the most important single invention ever made—for it led to some of the most far-reaching developments in the civilized world. At once it provided a device with which to build the entire present system of electrical communication, wire and wireless, telegraph, telephone, picture transmission and television. It has revolutionized the motion picture industry and given us the modern public address system. And in countless other fields it continues to improve and revolutionize operations and techniques.

At first De Forest merely introduced a third electrode into the tube which, by virtue of its proximity to the other elements, affected the current through the tube. This was in 1907 and this was the basis of his patent No. 814,387 taken out in that year. In 1908, however, he gave the third electrode the form of a grid placed in the space between the cathode and the plate. This idea is incorporated in patent No. 879,532 and is the fundamental principle involved in all* electron tubes today.

*Except certain special forms.—EDITOR

Portable Test Unit

Portable Potentiometer

Portable Loading Unit

A STANDARD ELECTRIC *Panel* FOR EACH PROBLEM

An impressive number of the nation's leading industries are making use of special electrical test and control panels — wall, bench or portable — which we have designed and manufactured to meet their exact needs.

The units illustrated and described here are some examples of our versatile designs. We offer you, without obligation, the personal services of our engineers to give you the advantages of their experience and to assist in the development of practical panels and units to meet your particular requirements. We also design and manufacture Precision Timers for a wide variety of purposes.

A letter stating your needs will bring a call from our nearest field representative and complete co-operation by our staff of manufacturing engineers. Our service is nation-wide. Address Dept. I-7.

THE STANDARD ELECTRIC TIME CO.

Specialists in this Line

SPRINGFIELD, MASSACHUSETTS

For Obtaining Electrical Indicating Instruments

For the convenience of *Instruments* subscribers there is reproduced below in facsimile the new WPB General Limitation Order L-203 as amended June 9, 1943; and the next four pages constitute a facsimile reproduction of WPB Form 1682. The instructions on page 4 of the form, and L-203, are self-explanatory. *Important.*—Do not tear along the fold: when tearing, tear the upper half of the entire form (pages 1, 2, 3 and 4) from the lower half.

WAR PRODUCTION BOARD

L-203
June 9, 1943

PART 3087—ELECTRICAL INDICATING INSTRUMENTS [1]

[General Limitation Order L–203, as Amended June 9, 1943]

The fulfillment of requirements for the defense of the United States has created a shortage in the production of electrical indicating instruments for defense, for private account and for export, and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 3087.1 *General Limitation Order L–203*—(a) *Definitions.* For the purpose of this order:

(1) "Person" means any individual, partnership, association, business trust, corporation, governmental corporation or agency, or any organized group of individuals whether incorporated or not.

(2) "Manufacturer" means any person engaged in the production, assembly or fabrication of electrical indicating instruments.

(3) "Electrical indicating instrument" ("meter") means a measuring mechanism the pointer of which responds to a change in an electrical quantity. The term shall include instrument mechanisms and instrument relays made therefrom; also, small panel, switchboard, portable, and aircraft electrical instruments. The term shall not include:

(i) Any multi-purpose portable instrument capable of measuring more than one electrical quantity and embraced within the classification of electronic test equipment in General Scheduling Order M–293;

(ii) Any instrument made with metal bearings and normally used in automotive vehicles or mobile construction machinery;

(iii) Any electrical aircraft self-synchronous indicator or transmitter.

(4) "Approved order" means any order which is embraced within any one of the following categories: *Provided,* That no order shall be brought within the provisions of subparagraphs (i), (ii) or (iv) of this paragraph (a) (4) by the subdivision thereof or by any subdivision of requirements:

(i) Any order for less than 500 identical electrical indicating instruments which conform to the ranges and dimensions established and prescribed for "Electrical indicating instruments" by American War Standard C39.2—1943, as approved January 6, 1943, and published by American Standards Association;

(ii) Any order for less than 500 identical electrical indicating instruments of flange diameter, height, or width exceeding 3½";

(iii) Any order for polarized vane non-jewelled instruments;

(iv) Any order for less than 500 identical electrical indicating instruments which conform to approved United States Army or Navy specifications specified on the order;

(v) Any order authorized in writing by the War Production Board on Form WPB–1682.

(b) *Restrictions on acceptance and delivery of orders.* (1) No person shall place on a manufacturer and no manufacturer shall accept any order for electrical indicating instruments other than an approved order.

(2) No manufacturer shall deliver, and no person shall accept delivery from any manufacturer of any electrical indicating instruments in fulfillment of any order placed hereafter unless such order is an approved order.

(3) Any person who places, accepts or fills an order authorized on Form WPB–1682 shall comply with such restrictions and conditions as may be specified thereon.

(c) *Production equipment.* No manufacturer shall produce, or cause to be produced, fabricated or assembled, any tools, jigs, dies or other production machinery or equipment designed for the manufacture or production of electrical indicating instruments of types, ranges, sizes and specifications not embraced within the categories of approved orders defined in paragraphs (a) (4) (i) or (a) (4) (iv) hereof: *Provided, however,* That the provisions of this paragraph shall not apply to the maintenance, repair, replacement or improvement of existing tools, dies, jigs, and other production machinery equipment. The provisions of this paragraph shall not apply with respect to the manufacture of polarized vane non-jewelled instruments or instruments of flange diameter, height or width exceeding 3½".

(d) *Scheduling.* On or before the fifteenth day of each calendar month every manufacturer shall file with the War Production Board his proposed delivery schedule for electrical indicating instruments for the following month, and such other information as is required thereby on Form WPB–1685. The delivery schedule for the calendar month following the filing shall be deemed to be approved by the War Production Board upon receipt thereof, unless and until the War Production Board shall otherwise direct, and shall be deemed a frozen schedule within the meaning of Priorities Regulation 18. No manufacturer shall alter any such approved delivery schedule except pursuant to a written direction of the War Production Board which identifies the frozen schedule and states on its face that it is an amendment of that schedule.

(e) *Special directions and exemptions.* (1) The War Production Board may from time to time issue in writing in respect to electrical indicating instruments special orders or directions which:

(i) Alter or freeze delivery or production schedules, in whole or in part;

(ii) Direct the cancellation of any order held by any manufacturer;

(iii) Allocate any unfilled order from one manufacturer to another manufacturer;

(iv) Direct the delivery of any electrical indicating instrument in production or completed to any person at the established price and terms;

(v) Authorize exception or departure from any of the provisions of paragraph (c) hereof; or

(vi) Take such other action as it deems necessary with respect to the placing of orders for, or the production or delivery of electrical indicating instruments or any component parts thereof.

(2) The provisions of this order, other than the provisions of paragraph (e) (1), shall in no event be construed to apply to the maintenance or repair of electrical indicating instruments, nor to purchase orders for component parts of electrical indicating instruments required for the maintenance or repair thereof.

(f) *Applicability of regulations.* This order and all transactions affected thereby are subject to the provisions of all regulations of the War Production Board, except that to the extent of any conflict or inconsistency therewith the provisions hereof shall control.

(g) *Violations.* Any person who wilfully violates any provision of this order, or who, in connection with this order wilfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime and upon conviction may be punished by fine or imprisonment. In addition any such person may be prohibited from making or obtaining further deliveries of, or from processing or using materials under priorities control and may be deprived of priorities assistance.

(h) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(i) *Communications.* All reports to be filed, appeals and other communications concerning this order should be addressed to War Production Board, Radio and Radar Division, Washington, D. C. Ref: L–203.

Issued this 9th day of June 1943.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

[1] Formerly Part 3087—Combat Measuring Instruments.

WPB-1682
RLY PD-674
-43)

UNITED STATES OF AMERICA
WAR PRODUCTION BOARD

APPLICATION FOR AUTHORIZATION

O RECEIVE DELIVERY OF ELECTRICAL INDICATING INSTRUMENTS

(THIS APPLICATION NOT TO BE USED AS AN APPEAL)

BUREAU OF THE BUDGET NO. 12-R132
APPROVAL EXPIRES OCTOBER 5, 1943

CASE NO. *(Do Not Fill In)*

WPB ORDER NO.
L-203

War Production Board, Washington, D. C.
Radio and Radar Division, Electrical Instrument Unit

SEE REVERSE SIDE FOR INSTRUCTIONS

TIONS FOR INSTRUMENT MANUFACTURER

- TEAR HERE -

APPLICANT - DO NOT FILL IN

HORIZATION IS HEREBY GRANTED/DENIED TO TRANSACT IN THE REQUESTED TRUMENTS IN THE MANNER SET FORTH ON THIS APPLICATION, SUBJECT TO FOLLOWING CONDITIONS:

THAT THE APPLICANT WILL DETACH THE UPPER PORTION OF THIS APPLICATION AND TRANSMIT THAT PORTION *ONLY* TO THE MANUFACTURER WITH *THE APPLICANT'S* PURCHASE ORDER.

CASE NO. *(Do Not Fill In)*

WPB ORDER NO.
L-203

APPROVED _____

GPO—War Board 5806A—p. 1

FORM WPB-1682 FORMERLY PD-674 (5-28-43) | PAGE 2 OF 4 PAGES

PART I

INSTRUMENT MANUFACTURER	ADDRESS *(Street, City, State)*

LINE NO.	PURCHASE ORDER			INST. MFGRS. QUOTATIONS *(Days)*			INSTRUMENTS REQUESTED			NO. REQU
	NUMBER	DATE	ITEM NO.	START	COM-PLETE	DATE	QUANTITY	MODEL	DESCRIPTION *(Range - Volts, Amps Etc.; Specification No.: Etc.)*	PER ASSEM
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

-TEAR HERE-

PART II

1. FOR WHAT PURPOSE ARE THE INSTRUMENTS TO BE USED? INDICATE TYPE OF PRODUCT IN WHICH INSTRUMENTS ARE TO BE INCORPORATED AND REPORT ULTIMATE USER.

2. WILL THE PURCHASE ORDER BEAR A PREFERENCE RATING? *(Give Details)*

3. DO THE REQUESTED INSTRUMENTS MEET ASA STDS. OR ARMY-NAVY SPECIFICATIONS? *(If not, why? Explain any special features.)*

FILL IN ITEMS 4, 5, 6, AND 7 INCLUSIVE IF APPLICABLE TO THIS REQUEST

4. IF INSTRUMENTS ARE FOR REPLACEMENT, WHAT ATTEMPT HAS BEEN MADE TO REPAIR PRESENT UNITS? *(Explain why instrum cannot be repaired.)*

GPO—War Board 5800A—P

WPB-1282 FORMERLY PD-674 (5-28-43)

PART I

INESS OF APPLICANT	DATE OF THIS APPLICATION	NAME AND ADDRESS OF APPLICANT

ENTORY RST OF RRENT ONTH	NO. OF IDENTICAL INSTRUMENTS DUE FROM OTHER ORDERS FOR THIS PURPOSE	DELIVERY REQUESTED 194 TO 194 *(Do Not Fill In "Authorized" Column)*								LINE NO.
		(Month)	(Month)	(Month)	(Month)	(Month)	(Month)	NEXT THREE MONTHS	REQUESTED / AUTHORIZED	
									REQUESTED	1
									AUTHORIZED	
									REQUESTED	2
									AUTHORIZED	
									REQUESTED	3
									AUTHORIZED	
									REQUESTED	4
									AUTHORIZED	
									REQUESTED	5
									AUTHORIZED	
									REQUESTED	6
									AUTHORIZED	
									REQUESTED	7
									AUTHORIZED	
									REQUESTED	8
									AUTHORIZED	
									REQUESTED	9
									AUTHORIZED	
									REQUESTED	10
									AUTHORIZED	

TEAR HERE

PART II

WHAT NUMBER OF UNITS ARE REQUIRED TO FILL CUSTOMERS ORDERS NOW ON HAND HAVING THE FOLLOWING RATINGS?

ODE	AA-1 AA-2	AA-2X	AA-3	AA-4	AA-5	OTHER	AV. NO. OF UNITS REQ. PER MONTH

PRECEDENCE LIST URGENCY NO.	QUANTITY OF PRIME EQUIPMENT REQUIRED *(Enter Month Below)* DATE OF PRIME CONTRACT:						
	(Month)	(Month)	(Month)	(Month)	(Month)	(Month)	NEXT THREE MONTHS

PRIME EQUIPMENT	PRIME CONTRACT NO. CLAIMANT AGENCY	SUB-CONTRACT ASSEM.	NO. ASSEM. PER EQUIPMENT

NAME AND ADDRESS OF APPLICANT

PREFERENCE RATING

LEAD FACTOR IN DAYS

NO. ASSEM. SPARES PER EQUIPMENT

IME CONTRACTOR	SUB-CONTRACTOR
ODUCED BY PLANT AT	PRODUCED BY PLANT AT

GPO—War Board 5806A—p. 3

CERTIFICATION - THE UNDERSIGNED COMPANY, AND THE OFFICIAL EXECUTING THIS CERTIFICATION ON ITS BEHALF, HEREBY CERTI
THAT THE INFORMATION CONTAINED IN THIS REPORT IS CORRECT AND COMPLETE TO THE BEST OF THEIR KNOWLEDGE AND BELIE

NAME OF COMPANY — BY — SIGNATURE OF AUTHORIZED OFFICIAL

DATE — TITLE

SECTION 35(A) OF THE UNITED STATES CRIMINAL CODE, 18 U.S.C. SEC. 80, MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FA
STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTI

INSTRUCTIONS

This application shall be used to request authority to receive delivery of Electrical Indicating Instruments which may not be purchased on an order which is automatically approved under paragraphs (a) (4) (i), (a) (4) (ii), (a) (4) (iii), or (a) (4) (iv) of L–203. Any order specifying instruments which deviate from standards defined in paragraphs (a (4) (i) or (a) (4) (iv); or, any order for 500 or more identical instruments classified in paragraphs (a) (4) (i), (a) (4) (ii), or (a) (4) (iv), whether standard or not, must be approved by the War Production Board on this Form.

When making an application, this Form is to be submitted by the instrument purchaser in triplicate to the War Production Board, Radio and Radar Division, Electrical Instrument Unit Ref. L–203, Washington, D. C.

Fill in the information required in Part I for each instrument item you desire to purchase. In Part II answer Items 1, 2, 3, and fill in Items 4–7 inclusive where applicable to your particular request. (See specific instructions below). A separate application must be filed for each instrument manufacturer from whom delivery will be received; and, where instruments are ordered for more than one prime contract on one instrument manufacturer, a separate application must be filed for each prime contract.

(a) *Prime Contractors.*—For the purpose of this application a prime contractor is a manufacturer having a contract directly from the Government (Army, Navy, or other Federal Agencies), and prime equipment is the end-product being purchased thereon.

Prime contractors purchasing instruments for incorporation into their products will submit one application for *each* prime equipment as to each instrument manufacturer. For example, if there are several sub-assemblies of the prime equipment requiring one or more items of instruments and the prime equipment manufacturer is manufacturing these sub-assemblies himself, only one application should be submitted since the units will all be used in the same prime equipment.

Part II, Item 5 does not apply to prime contractors.

In Part II, Item 6, show the precedence list urgency number, if any, and the quantity of prime equipment required per month. The precedence list schedule should be shown for those months in which the prime equipment using the instruments is required, and will differ from the instrument schedule by the lead factor. In the event a precedence list number has not been assigned, enter in this section of the report "no precedence list number assigned".

In Part II, Item 7, identify the prime equipment by name, specify the prime contract number, date, preference rating of prime contract, instrument lead factor in days, and plant of prime contractor. Also the number of assemblies per prime equipment and number of assembly spares per prime equipment if applicable.

(b) *Subcontractors.*—For the purpose of this application a subcontractor is a manufacturer having a contract from a prime equipment manufacturer, whose end-product is a sub-assembly of the prime equipment.

Subcontractors who are the purchasers of instruments will file one application for *each* prime equipment as to each instrument manufacturer. For example, if several sub-assemblies are for the same prime equipment, and each sub-assembly requires one or more instruments, file only one application provided the instruments cannot be purchased on an otherwise "approved" order as defined in L–203, and are to be received from the same supplier.

Part II, Item 5 does not apply to subcontractors.

Fill in Items 6 and 7 of Part II in accordance with instructions in Par. (a). Also identify the subcontract assembly and give location of subcontractor's plant.

(c) *Other.*—Persons using instruments for incorporation into products such as test sets, welders, analyzers, etc., which are to be sold on the commercial market, including Government purchases, must file an application as to each manufacturer if the instruments cannot be purchased on an otherwise "approved" order.

Government orders may also be placed for these products, but under such circumstances the product should not be considered as prime equipment. For the purpose of this application, a specific product is not considered prime equipment if it is sold on the commercial market and delivered on other orders which are not solely Government orders.

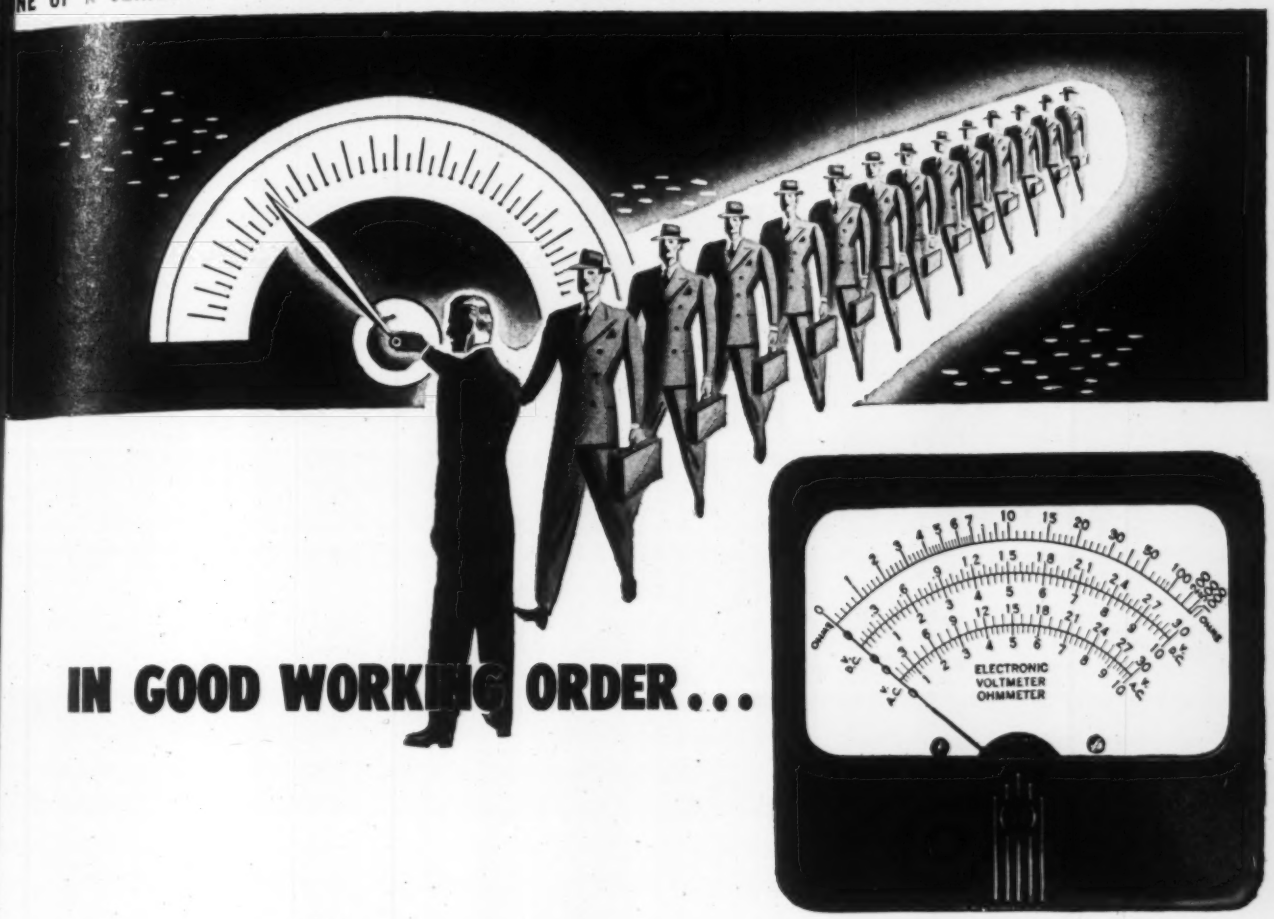
If the instruments requested in Part I are to be incorporated in more than one type of product, list each such type of product in Part II, Item 1, and identify by assigning a code symbol. Repeat this code in Item 5 and show the number of requested instruments required to fill customer's orders on hand for each product having the various priority ratings as shown. Do not repeat orders which have been included on previous WPB 1682 (PD–674) applications.

Fill in Part I and Items 1, 2, 3 and 5 of Part II.

(d) *Replacement and maintenance.*—Standard instruments should be purchased wherever possible. If standard instruments cannot be used, explain fully in Item 3 of the application why standards cannot be used. Submit one application as to each instrument manufacturer and fill in Part I and Items 1, 2, 3 and 4 of Part II.

GPO—War Board 5806

ONE OF A SERIES OF ADVERTISEMENTS SHOWING DeJUR PRECISION PRODUCTS IN ACTION ON THE HOME FRONT



IN GOOD WORKING ORDER...

America is watched over by people... "little people"... the policeman, the druggist, the shopkeeper, the repairman and so on. Bulking large in the life of the community these days is the radio serviceman... he's got to keep present sets operating for the duration.

Because his must be dependable equipment, you'll find that a DeJur Meter is the heart of his sensitive testing and checking apparatus. He has learned from long and constant use that this meter is consistently accurate, that it can take a lot of punishment, and that it can save precious time by enabling him to get to the bottom of the trouble immediately. For the fine job that the Radio Servicemen are doing in wartime America, the needle of the DeJur Meter points with pride.

KEEP BUYING WAR BONDS AND STAMPS

ARMY E NAVY

Awarded for Excellence in Production and Quality of Material

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SHELTON, CONNECTICUT

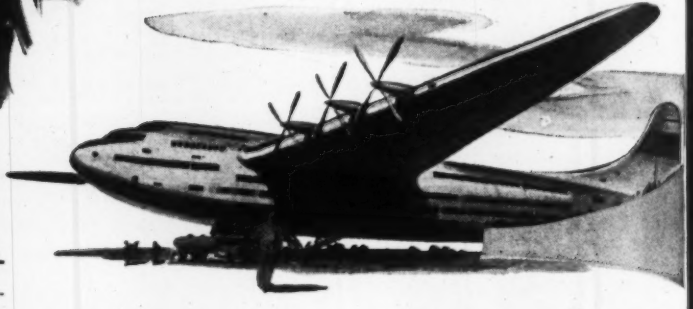
NEW YORK PLANT: 99 Hudson Street, New York City • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto

"We feed these babies with a measuring spoon!"

THE modern aircraft engine has the power to move a freight train. Yet it weighs less than a pair of ordinary car wheels. The secret of its tremendous output without the need for massive parts lies in large measure in microscopic balances, high speed, and high efficiency, together with the miracle of modern alloys. Its power is smooth and tremendous when under instrument control . . . but is gone in a flash—along with a plane and a pilot, perhaps—if it is ineptly handled. Kollsman engine instruments—tachometers, manifold pressure gages, thermometers—are what give the pilot control over the torrent of power which propels him through the skies. Upon their precision and reliability has been built not a little of aviation's current advancement. Their role in tomorrow's progress is an even greater one.

THE KOLLSMAN ELECTRIC DUAL TACHOMETER AND SYNCHROSCOPE *not only registers engine revolutions in twin-engined planes, but directly compares the speed of the engines to permit perfect synchronization. It is electrically operated, with generators on the engines sending power impulses by wire to the indicators on the instrument panel.*

WHAT TOMORROW'S AIRCRAFT ENGINES *will look like or how they will perform, we don't know yet. But we do know that instruments will play a large part in expanding their scope and usefulness far beyond anything we know today. Kollsman engineers are constantly developing new and better aircraft instruments which will help widen and extend tomorrow's skyways for a new era in aviation.*



KOLLSMAN AIRCRAFT INSTRUMENTS

PRODUCT OF

SQUARE D COMPANY

ELMHURST, NEW YORK — GLENDALE, CALIFORNIA

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

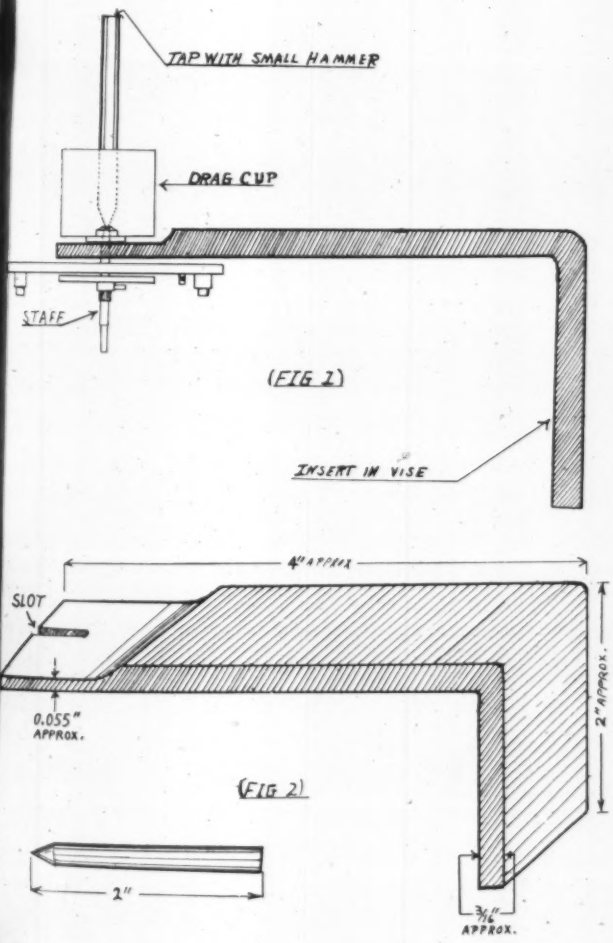
Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. II, No. 7 M. F. Behar, Editor JULY 1943

Removing Drag Cup from Pioneer MK V Electric Tachometer

By RANSOM J. BURT
1225 Edgewood Ave., Jacksonville, Fla.

TO mechanics working on Pioneer electric tachometers often comes the time to remove the drag cup. This cannot be done without injury to the cup or staff unless some tool is used that is made for this particular purpose. I made a tool of this type several months ago and have found that it does the job very satisfactorily. It is easy to make and use as can be seen from the illustrations.



(FIG 1)

(FIG 2)

A piece of flat iron approximately six inches long, one inch wide and three-sixteenths inch thick is used. About two inches of the piece is put in a large vice and the remaining end is bent over so the piece takes the shape of a capital "L" as shown. (A soft grade of iron can be used and it can be bent cold.) Using a hack-saw, a slot is sawed in the long end of the piece as shown in Fig. 2 (approx. one half inch deep). Now the top part of the long end is ground or filed down until the cup and staff will fit over it. It is essential that this surface be smooth and flat. Now make a punch with the small end about the size of the cup staff as can be seen from the inside of the cup.

To remove cup, first mark the position it comes to rest with the complete movement together. It can be marked in relation to the hairspring stud (this is important). Disassemble the movement, unpinning the hairspring. Put the short end of the tool in a small bench vise, put the movement in place, set the punch on the end of the staff and tap lightly with a small hammer. It will be found that the cup will usually be removed with the first tap. Note: Assuming the mechanic has had some experience of this sort, the exact dimensions have been omitted because this tool can be made in any number of sizes.

Re: Gyro Instrument Tests

By GEORGE R. FORD
(with our Armed Forces overseas)

(1)

IN the overhaul of the Directional Gyro, after completing the balance of the horizontal gimbal ring in accordance with instructions, revolve the rotor to 1000 r.p.m. or less. Rotate the ring in its fixture. If properly balanced it will remain stationary when stopped in any position during its complete revolution. Vibrate the fixture and do not speed the rotor.

(2)

Before fitting the dial to the vertical ring in overhauling the directional gyro, place the assembly in the balancing fixture. You will note the preponderance of weight on the 90° end. By attaching a rectangular lead weight to one or both of the caging arm adjusting screws, between the locknut and the arm, a near balance can quickly be made. The time necessary to balance the vertical ring will be greatly reduced and the balancing weights more uniformly spaced.

(3)

A practical vibrator for use in preliminary tests of Directional Gyros, Horizons and Pilots may be made from a discarded "buzz wheel" instrument. The Turn and Bank is ideal. Add a sufficient amount of solder to the rotor to throw it off balance and attach the instrument to the test fixture, which should rest on sponge rubber: 2" squares cemented to wooden tops preferred. Regulate the air intake or use a valve to allow the vibrator to run on approximately

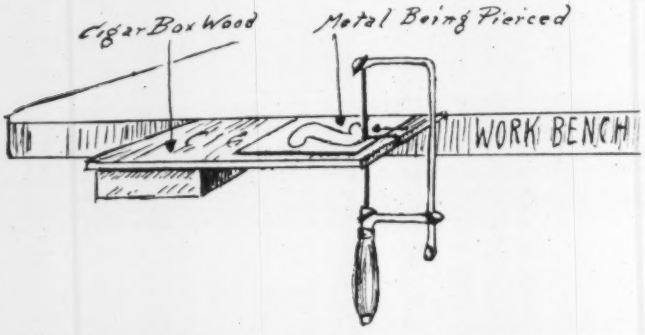
1½" of mercury. In order to start the unbalanced rotor it may be necessary to give it a boost by raising the mercury for an instant.

By using ample size, uniform connections and lines, one is able to test two Directional Gyros and also run a coast test at the same time, e.g., in testing the DG's the mercury will probably stand at 4" (suction). The number of inches the mercury is raised above this point by opening the compression line, represents the force being applied to the coast test.

Piercing Thin Metal with Jeweler's Saw

By GEORGE E. KERN
20th Airdrome Squadron, Army Air Base, Salina, Kansas

WHEN a special shape is required from thin metal (shim stock, etc.), the outline is first scratched on the stock. The metal is then laid on a piece of thin wood (cigar

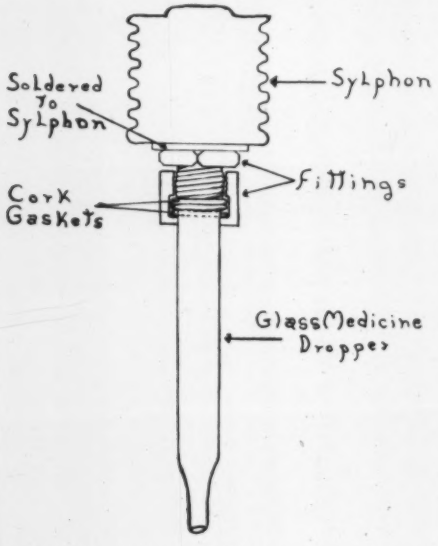


box pieces are about right). Proceed with the piercing, sawing through the wood as well as the metal. Care should be used in keeping the fingers well placed to hold the metal firmly down. The finished piece will be flat, free of wrinkles or bends.

Instrument Oiler

By GEORGE PEFFER
Paine Field Sub Depot, Everett, Washington

THIS handy oiler, an improvement over the conventional medicine dropper, can be made of parts found around the shop. Remove the rubber bulb from an ordinary dropper

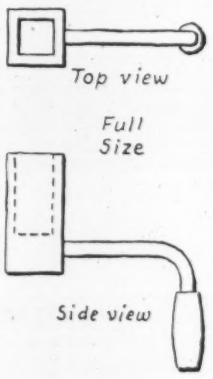


and replace it with a metallic bellows of convenient size such as the one found in some suction and manifold pressure gages. Threaded brass fittings soldered to the bellows and cork gaskets complete the assembly. Such an oiler proved satisfactory to gyro work where the rubber bulb on the ordinary dropper soon deteriorates. It is useful also when working with other liquids such as carbon-tet.

Hand Crank for Chronometric Tachometer Shaft

By OLIVER WARNER
Instrument Repairman, 19th Sub-Depot,
Army Air Base, Chico, Calif.

INSTRUMENT men who repair the chronometric tachometer in any number will find this bench tool helpful. It is simply a small hand crank to turn the drive shaft a test motor would do. Although only low r.p.m. readings may be gained, the crank is useful when repairing and checking pointer return, zero setting and reversing gear operation. A drive shaft frozen into the tachometer housing, will often cause the whole instrument to revolve at the rate the test motor is turning. As a safety feature, one of these hand cranks should be kept near the tachometer test stand to be used in making sure the tachometer drive shaft is *not* frozen. The illustration here with shows the crank full-size.



AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

812 N. DELAWARE PLACE
TULSA, OKLAHOMA

The following articles (to the bottom of Page 434) have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

Horizon Rotor Shimmying

By R. G. OJERS
Guild President
Spartan School of Aeronautics, Tulsa, Okla.

WHEN we breathe, it is to give us continuation of life. When a gyroscopic Auxiliary Horizon instrument breathes, it is the beginning of its death. A number of theories have been expounded on this breathing or, as some may call it, shimmying. In either instance, it is the lack of perfect concentricity in the rotor. It is not readily found or, when it is found, it is usually considered insufficient to

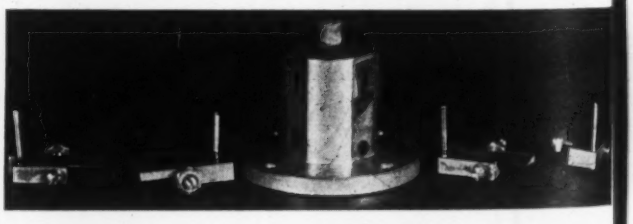


Fig. 1

create difficulty. This may be true—it won't immediately, but due to this breathing, or oscillation, the pendulum vanes keep up a rocking or swinging motion that wears and wears, which is the cause of the instrument failure resulting from the worn condition shown in Fig. 1.

Let us start at the beginning. A mechanic, in reconditioning the parts of an instrument in preparation to its

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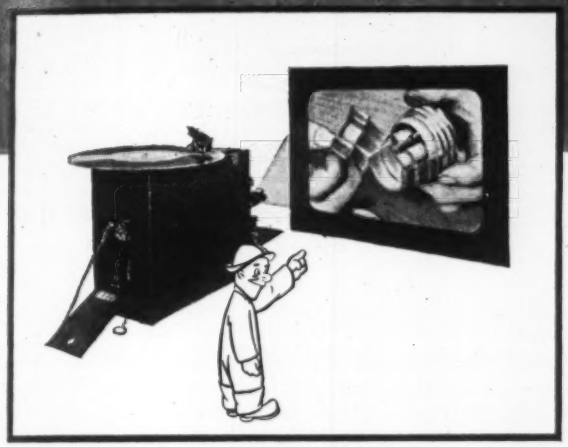

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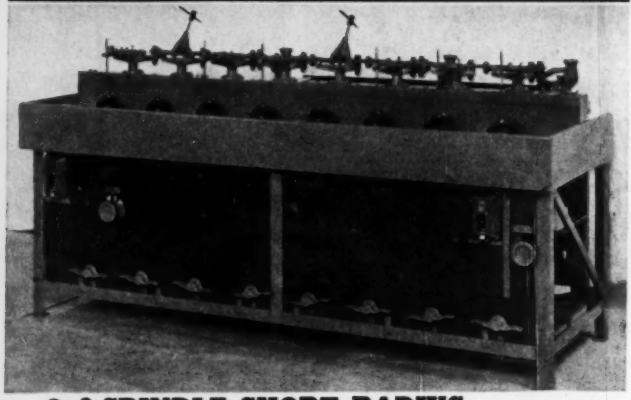

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assembly, balances the rotor until it is good to the feel; or when an automatic balancer is used, until it works to a certain tolerance of vibration—usually well within reasonable limits of perfection.

But this condition is due to the rotor not being in perfect concentricity, although to such a minute extent as to be considered negligible by our sense of feel, or by the electrical indication of the automatic rotor balancing machine. Our biggest difficulty is in differentiating between "out of concentricity" and "out of balance."

You may wonder why a rotor that is "smooth" enough to pass inspection in the housing could cause trouble after

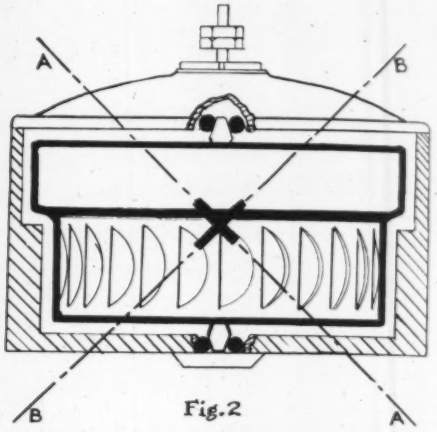

Fig. 2

the instrument is assembled. Let us refer to Fig. 2. It is our opinion that a rotor slightly out of concentricity, although perfectly balanced, will have a small amount of oscillation that finds its center of axis where the line *A-A* bisects *B-B*. (Note the equal distribution of mass weight.)

Now refer to figure No. 3. Please note the lowered position of the center of balance shown where line *A-A* bisects *B-B*, caused by the added weight of the pendulum body. Please note also that, due to this lowering of center of

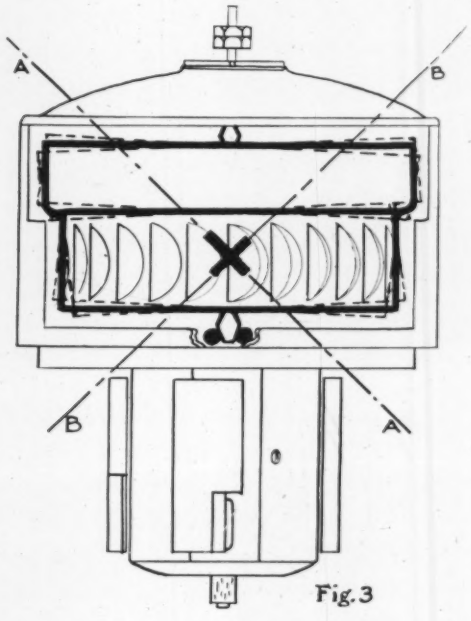

Fig. 3

pivoting, the original minute amount of oscillation has been increased considerably; and, since our pendulum vanes are mounted so as to be free to swing under provocation, they will do just that, creating the worn condition shown in Fig. 1. Also they cause the ultimate instrument failures that are so disagreeable to the pilot, costly to the operator—and a setback for the mechanic in finding out that he performed a job "unwell."

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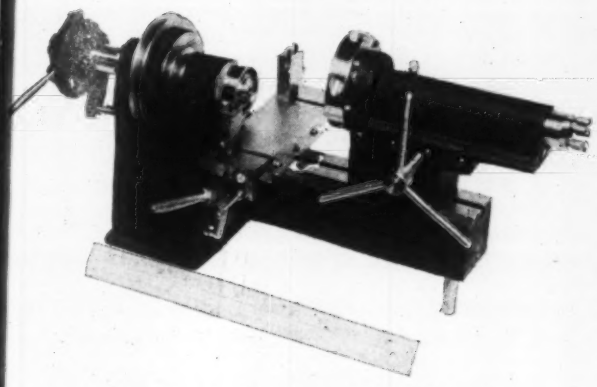

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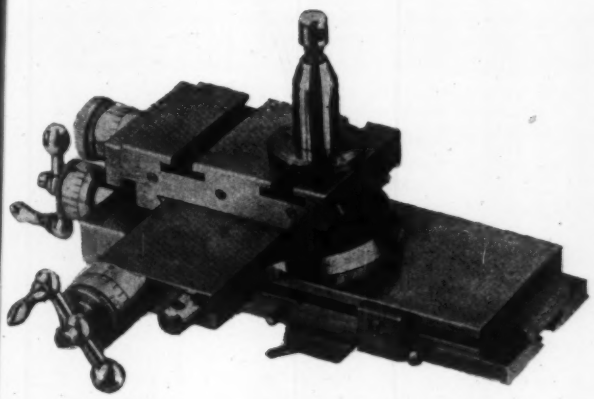

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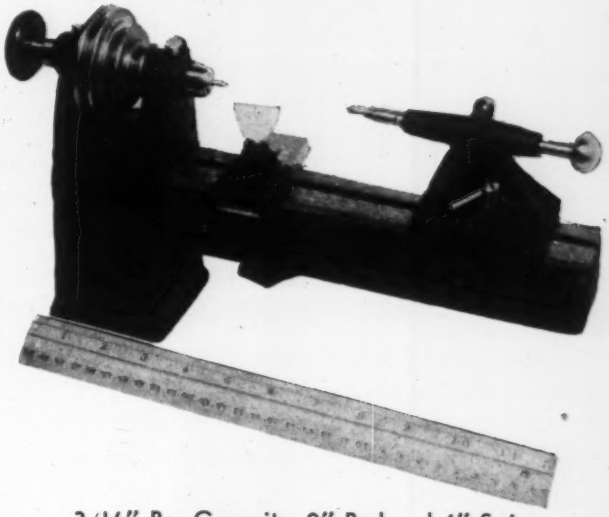

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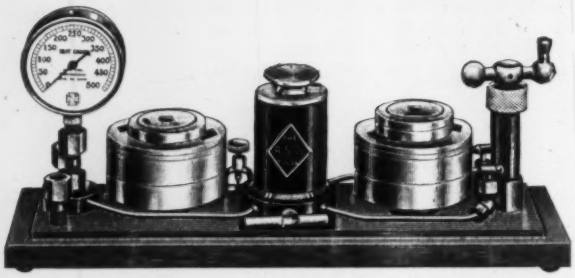

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Standardization Through Cooperation

By R. G. OJERS
Spartan School of Aeronautics, Tulsa, Okla.
President, Aircraft Instrument Guild

ONE of the first duties of a manufacturer is to know what the public desires or will need; then build it. Second, the article or unit must be quantity-produced, so that its cost will not be prohibitive to the little man. Last but not least, it must give good service, which means that if it is a technical product its design and construction must assure longevity of operation, maximum accuracy and efficiency with minimum maintenance.

The field of aircraft instruments is no exception.

A few years ago, as at present, it was a condition largely due to competition and the survival of the fittest, since the manufacturers were trying to outdo one another in designing what they regarded as superior instruments, regardless of cost.

The commercial operators, following the same trend, were attempting (and in most instances, successfully) to cope with the rapid advancement of aviation.

All this time the private operators have been struggling along from the earliest brainstorms to the present-day achievements. As to the latter, the majority of these operators owning the standard pleasure-craft and light business-planes were well-to-do individuals or flourishing companies, so that cost was of little concern.

We as mechanics are not attempting to revolutionize the present procedures of the instrument manufacturers, but to help them in their giant strides for achievement. Perfection is rapidly being gained by their own engineers and the engineers and scientists connected with the N.A.C.A., the Bureau of Standards, the Guggenheim Laboratories and other institutions—not by pulling rabbits out of the hat but good old "down to earth" design and construction. Through long years of experience they have learned to anticipate our needs, in some instances years before conditions brought about the necessity of instruments being mass-produced.

The various manufacturers have long been sending out experimental models of instruments to the commercial airlines and the Army and Navy, for trial runs to catch their performances in actual operation under varying conditions —in climates cold, hot, wet, dry, high and low, dust and sand, after which this information was accumulated, consolidated and digested and the important life-giving factors were put into the instruments for production. But one phase, while not entirely neglected, was given somewhat of a backseat. I refer to economy in maintenance.

Economy covers a large field and there are many points of discussion, pro and con. I will confess that the problem is too weighty for any one individual to comprehend or solve, and so, in all fairness, a subject of this magnitude should be open for discussion. In fact, we should do all possible to encourage the writing of articles by mechanics and by executives far and wide, manufacturers, private owners and commercial operators. The airlines may look upon this as a minor item in comparison with propellers, engines, and even aircraft; but remember, these are to be included. It wasn't so long ago when the subject of maintenance man-hours was seriously considered; and it won't be very long until it will be again.

At present, the private owners will say "Most of our planes have been taken away from us or grounded, so why should we give it much consideration?" A large majority of the mechanics will say "Regardless of what comes out, we will fix." The manufacturers are busy trying to meet schedules and supply instruments in large enough quantities. On the whole, the present situation makes it difficult for any individual, company or single group to spend much time on the one important factor—designing and building for economy—standardizing for economy.

These instruments were run through the various opera-

Dynamic

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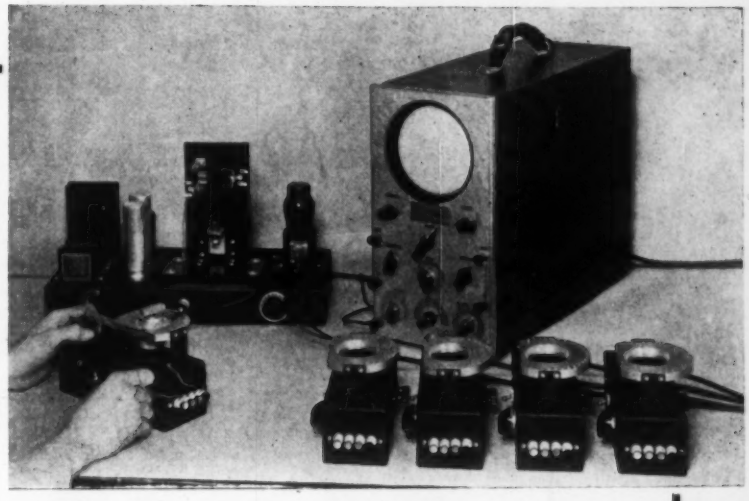

Illustration shows final checking of Model 39 Autosyn Calibrator and Polarity Checker which will calibrate ten degree spaces with an accuracy of plus or minus two minutes. The Model 39 is especially adapted to *rapid* checking of standard or special autosyns.

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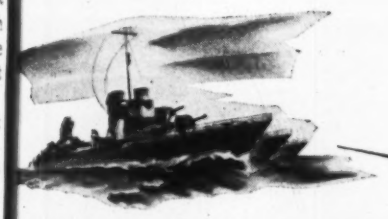

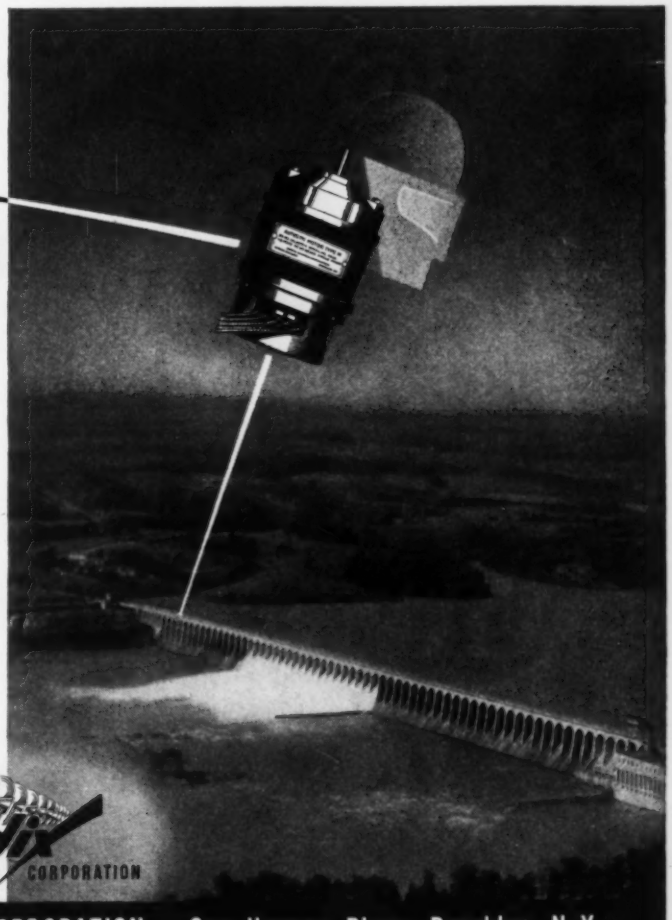

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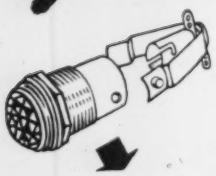

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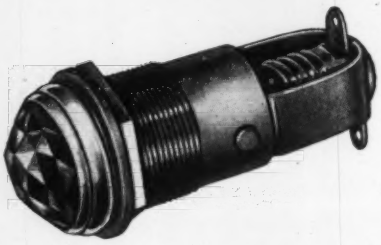

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tions for actual flight performances, but the mechanic w seldom if ever allowed to look at the inside of these expe mental units. Now for economy's sake, after a number hours of operation, allow a certified mechanic of each sh to overhaul completely this experimental model, after fi receiving instructions as to procedure from the factory. then will send in a full report, plus some of his own inf mation as to how this instrument should be overhaul using the tricks of the trade he has learned through actu experience in overhauling various types of instruments. T will be a definite help to the writing of service manuals.

Every mechanic who sends in such a report must course be a competent man. He must bear in mind the pec liarities of the instrument, its weak points and its stro points as to physical construction, its possibilities to wit stand shock and hard use. He must also bear in mind a suggest where it may be strengthened, where it may standardized, for more simplicity in maintenance. For e ample one new instrument must have bridges cut aw when possible to make all adjustable parts easily accessibl In particular, the mechanic should indicate where parts a material may be substituted from other instruments—suc parts as cover glasses, hands, pivots and, last but not lea screws.

The present non-interchangeability and non-standardiz tion of screws is a bigger headache than most people ou side instrument shops realize. We recently ordered two sp cial types of screws from a concern that specializes screws, after being refused shipment by an instrume factory. Yes, these could be obtained for $2.80 per gros plus *thirty dollars* for *each* type of setting-up of the nece sary equipment. Another example—a well-known Rate Climb uses thirty-six screws. Of these thirty-six screw there are *fourteen* different sizes and types. Investigati shows that *five* different types would be ample for this i strument.

All right, let's multiply this by all the types and mak of aircraft instruments in use today and it will explai why, in our screw cupboard, we have over one hundred a sixty different types and sizes of screws, and from thirt six to two hundred and eighty-eight of each type and si at a cost of $1.05 to $4.80 per gross! We pride ourselv in having one of the best collections of screws in existen for a shop of this kind, but the sad part is, we know ou stock is only one-fourth complete. Why? Lack of standard zation? Lack of coöperation? Certainly not lack of willin ness to coöperate. Can't anything be done about it?

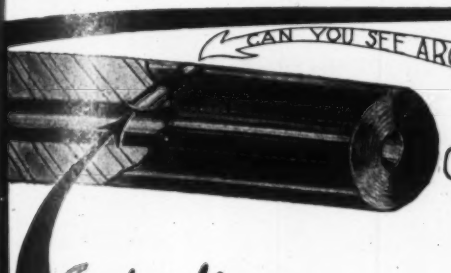
We all realize that the pressure of the war effort mak this difficult to consider at the present time, but isn't quite like the first shock of a cold shower that takes ou breath away, but the after-effects are so satisfying?

The airlines have a very concrete organization amon themselves and, even though they are competitors, the realize the necessity of close coöperation through standard zation.

I'm sure that if some organization would take the lea in a movement of this kind (not on screws alone but man other parts of instruments), everyone concerned would b more than willing to coöperate to the utmost to bring abou a more worth-while procedure of standardization whic would mean a saving to the operators of thousands of do lars in material and thousands of man-hours in labor, esp cially in times like these when good skilled instrument me chanics are so hard to obtain.

Through all the post-war planning, this should be ver close to the front of our minds. The writer, having jus returned from a trip back east, was amazed to find the tw extremes. One organization, in the wild scramble for produc tion, has been able to do little toward standardization fo economy's sake. Another organization had definitely planne this from the very start and its production and popularit have both climbed by leaps and bounds, but there is sti room for improvement. Others are making gallant stride with more or less success.

I found that without a single exception they were all ex-



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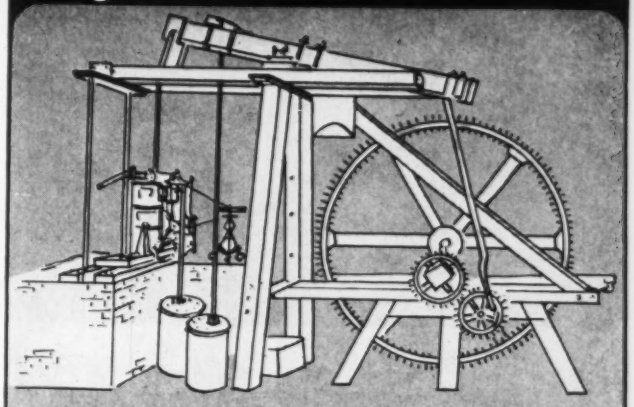

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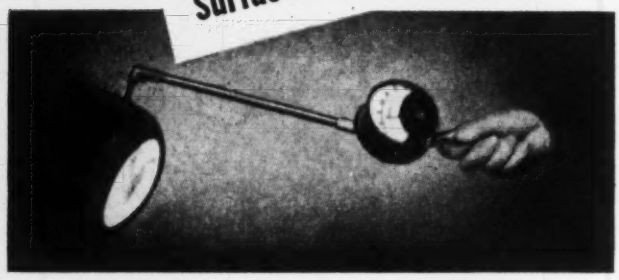

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tremely eager for help and coöperation to better this e
dition, which brings out the reason for this article.

Please allow me to repeat, this is too much for any one m
—there is room for a tremendous amount of debate. P
haps the first thing to be debated is initial cost. We c
appreciate in advance that costs are involved, but would
it prove to be far cheaper in the long run? I think so!

The aeronautical industry is the offspring of a marria
institution, capital and labor. So instead of the vario
accessories—hydraulics, engines, radio, instruments, etc.
being made separately then grafted to the main body, allo
these units to grow more directly from the trunk a
absorb from the heart of the industry the life-blood
vitally necessary for perfect harmony of growth, there
eliminating the need for so much surgical attention.

The A.I.G. Q&A Column

[NOTE—Guild Recorder E. M. Allsman, who conducted th
column from the start, has become associated with anoth
firm and his present employment is such that it is differ
for him to take care of Q&A. I am pinch-hitting until a
other regular Conductor can be assigned by the Guild.

We have received a number of requests for informati
from instrument mechanics who are non-members. Plea
let me explain that our space is limited and it is only fa
to answer the requests from members, although if tim
allows, we will answer all questions by letter and be gl
of the opportunity to be of service, whether you are a mem
ber or not.—R.G.O.]

* * *

*Q. Does centrifugal force have as much effect on a D
rectional Gyro as it does on an Auxiliary Horizon? (W.T.B
Chicago)*

A. No. Remember the Directional Gyro gimbal ring
balanced perfectly, both horizontally and vertically, befor
it will give perfect performance. If this is not done, th
centrifugal force may play a small part if maintained fo
a long enough period.

* * *

*Q. If there is a noticeable vibration of the pointers in
Turn and Bank Indicator when in flight, should more o
less damping be applied to lessen vibration? This occur
when the fork assembly has been properly fitted to the ba
ance plate stud and there is not an excessive amount o
vibration from the rotor itself. (W.T.B., Chicago)*

A. You call it vibration, although I am inclined to be
lieve you are speaking of a swinging condition caused by
not enough damping, allowing the instrument to be over
sensitive, making it difficult to hold the hand on the key
stone, especially if the flying is a little rough. Yes, the in
strument should be damped. There are three kinds of hand
movement on a Turn and Bank Indicator: fluttering hand
caused by the fork assembly having too much play on the
balance plate stud; excessive swinging; not enough damp
ing, hand vibrating, rotor out of balance.

* * *

*Q. Is the Directional Gyro affected by the rotational force
of the earth? (W.T.B., Chicago)*

A. Yes. A Directional Gyro tends to maintain rigidity
in space. If it were possible to remove all friction, then the
rotation of the earth would have a pronounced affect on
the gyro. As an illustration, if the axis of a free-spinning
wheel is set in a horizontal attitude with one end pointing
north and with the wheel turning at a continuous rate of
speed, we shall find that for each hour that passes, the axis
has moved in azimuth (away from north) a definite number
of degrees. Of course the direction of rotation of the wheel
will govern the direction of movement. This phenomenon is
known as "precession" and is caused by the effect of the
earth's rotation and amounts to approximately fifteen de-
grees per hour. Now as far as we mechanics are concerned
(and pilots also) we need not trouble ourselves with this

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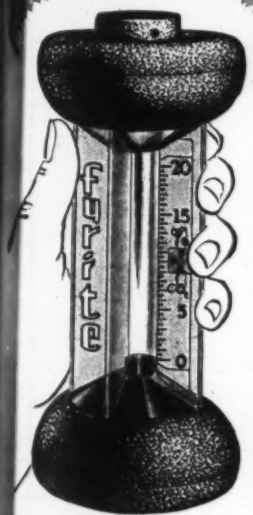

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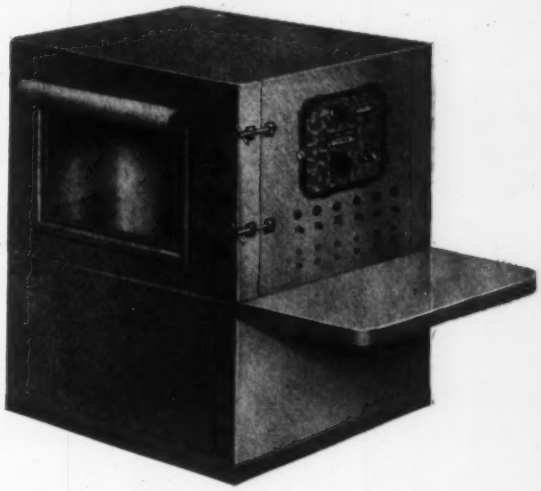

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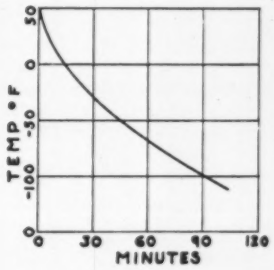

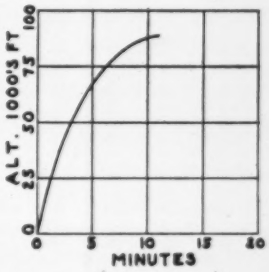

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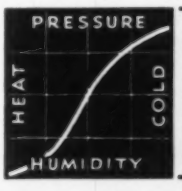

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* * *

Q. Why does the compass fluid turn dark after being in the plane so short a time? (M.C., Somewhere in Africa)

A. Compass fluid (standard) is an acid-free kerosene. The purer it is, the longer it will stay clear in a compass. It is the small amount of acid still remaining that becomes light-struck from the sun rays, causing it to turn a dark brown. You may be using an inferior quality compass fluid but another probable reason is that the sun's actinic rays are more intense in Africa than in most locations in the U.S.A. I would suggest that while the plane is sitting on the ramp, not in use, the compass be kept covered with masking tape to keep out the sunlight.

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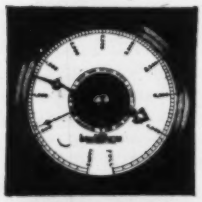

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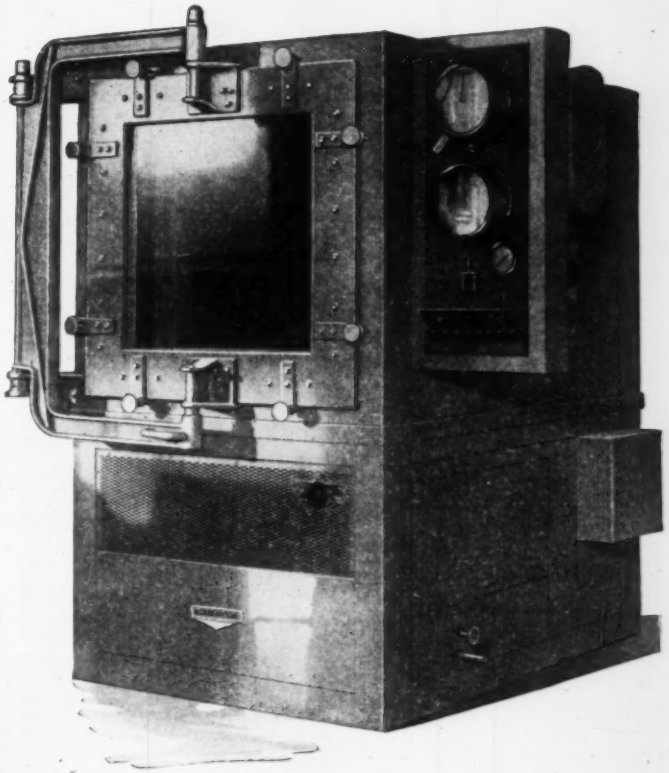

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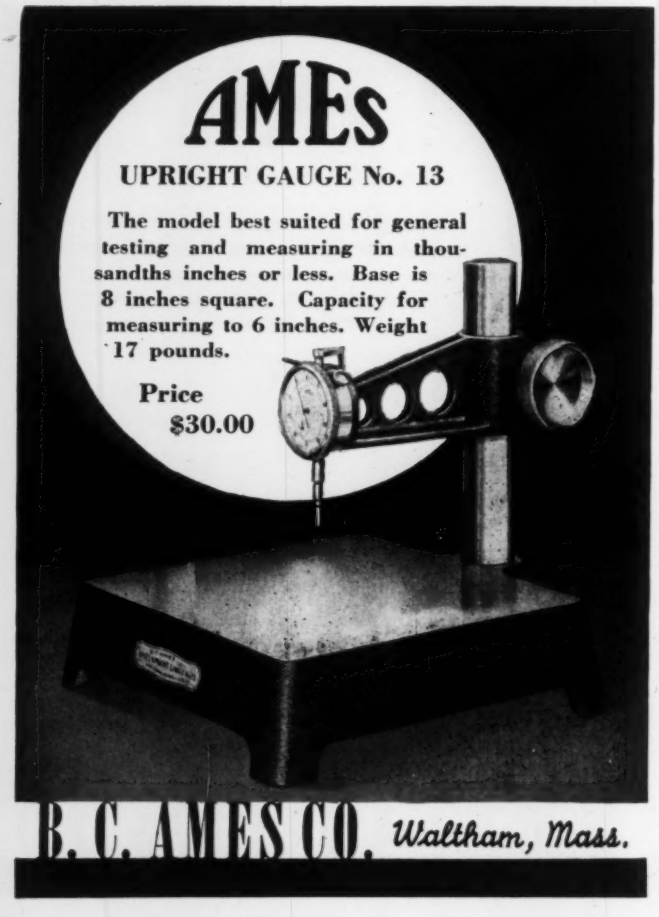
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Solving Control-valve Pressure-drop Problems

Concluded from page 400

other conditions might exist in that same circuit. All that is needed, then, is a *variable pressure regulator* instead of a valve for automatic control. Fig. 5 is a diagrammatic sketch of one scheme for accomplishing the desired result. The "zero balanced" regulator produces a pressure pattern on its outlet equal to the pressure pattern imposed from pipe line *a*.* A small pilot circuit is made with a regulator, valve and fixed orifice as shown. Between the control motor and the small valve is a cam which can be readily removed and replaced by another cam of different contour. Thus, any flow curve or pressure pattern is produced by the proper choice of cam. This particular pressure message or pattern is relayed to the main regulator where the same curve is superimposed upon the main flow circuit.

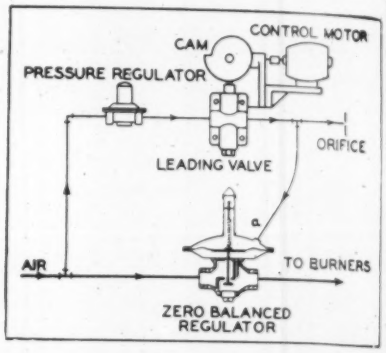
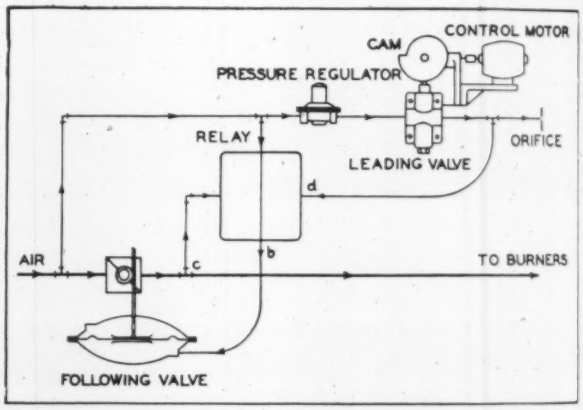


Fig. 5

Fig. 6

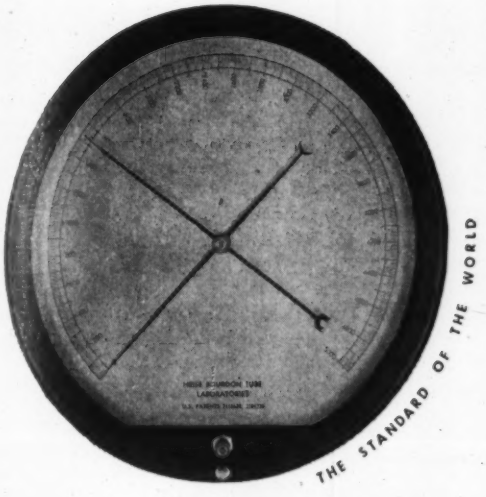


In practice, the main regulation is accomplished in two stages in order to maintain accuracy and to meet the no-pressure-drop requirement. A relay receives the message from the leading valve (see Fig. 6) and adjusts a pressure in pipe line *b*, moving the "following valve" until the pressure at point *c* is correct and in step with the pressure at point *d*. The following valve is a full-pipe-size butterfly valve giving no pressure drop when wide open. Thus, the above four requirements have been accomplished.

If it desired to maintain flow instead of pressure in case of a change in downstream resistance such as a clogging up of the burners, this may be accomplished merely by replacing the pressure tap at *c* with an orifice plate having pressure taps before and after.

For many years the control valve has been the uncertain factor in the perfection of instrument control. Now, with this new method, this uncertainty and limitation has been removed and the instrument may be further refined until practically all of the automatic control problems may be solved.

*H. C. McRae, "Simple Pressure Regulators—Principal Types and Their Characteristics." *Instruments*, Vol. 15, February 1942, pages 44-45, 59.



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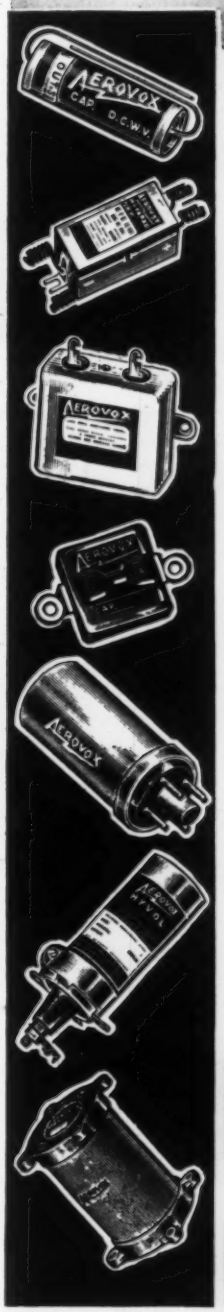

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Speaking of Control—on the Blackboard

(Concluded from page 393)

(first sketch, for example) it is the conjunctive element between the indication and the command. One simple form of such a brain consists in a pair of adjustable electric contacts whereby high and low limits are set; another simple form is merely a rigid connection between a deflecting element and a pilot valve. The pair of contacts, the pilot valve, the electron tube, the photocell, or what not, is *the prime relay*. Except in self-operating controllers, the brain commands the power unit or servomotor through a prime relay. In most cases the measuring element actuates the prime relay and it is difficult to realize that there is a brain. But when we classify the possible behavior patterns the analogy to a human being is inevitable—and fruitful! So, in addition to the four classes of relations listed above, other classifications were made. Examples:

1. Whether normality is a geometrical "point" or a definite dead zone; and if a dead zone, whether it is a desired adjustable differential between "high" and "low" or an undesired consequence of some imperfection.

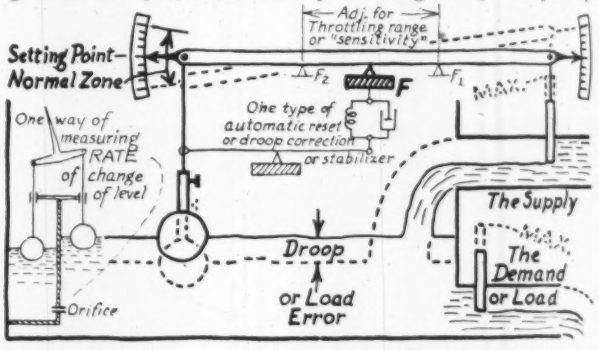
This bit of methodology (scientific approach through classification) led to the conclusion that there is no such thing as an automatic controller without a dead zone.

2. Whether the characteristic is modified when the deviation is *decreasing* (when the indication returns toward normality) instead of *increasing*.

3. Whether the indication is the deflection of a mechanical part or a change in an electromagnetic magnitude ("signal") making possible the use of an electronic or photoelectric prime relay and solving some lag problems.

And so on until the mere descriptions of some of the possible modes of control filled nine pages of small type. Incidentally, it was shown also that *the characteristics of the application* determine the grade or even the class of a mode of control. (For example, "on-and-off" is an absurdity in the absence of capacity or "flywheel effect" in the application—unless extremely rapid, as in illumination control where "all-or-nothing" alternations of 60 per second are undetected by normal vision.)

Anyway, the crux of the whole matter was that it is impracticable to name all conceivable or even all existing modes of control. It should be done on a quantitative basis. It should be done with curves! Meanwhile, some distinct classes of behavior became so well-known that categorical names emerged years ago: "on-and-off" and "throttling" (or "modulating" or other names). There isn't time to explain the development of the language but although we are dealing with *concepts*, a sketch representing *things* may help:

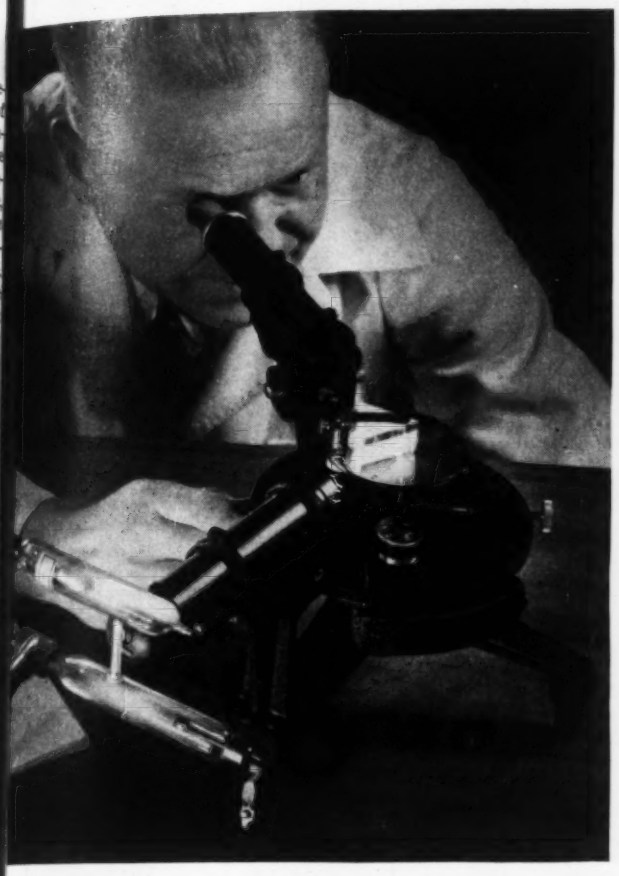


Look first at the heavy solid lines only. They show an arrangement giving a rigid mode of control which in 1930 we called "corresponding" but which is preferably called *proportional position* (not "proportional" alone, which sometimes means proportioning supply to demand without droop). The heavy solid lines show equilibrium at the setting point—demand and supply balanced. The heavy dotted lines show what happens when demand is maximal: in order to open the supply valve wide the float must droop below the setting point. Now look at the thin lines. First, the lateral shift of the fulcrum *F* which is the adjustment for throttling range. Imagine the "proportional sensitivity" doubled (F_2); the droop will be halved. Droop is proportional to throttling range or inversely proportional to "sensitivity." (Droop varies with load but is seldom exactly proportional thereto.)

Now what would a human brain do? Obviously, shift the fulcrum *vertically* as well as laterally, in order to take better care of load changes. This idea had been used decades ago in the Brown-Boveri, Smoot, Askania, Hagan and other big "regulators" and it was adapted to the "instruments." See the arrangement drawn in thin lines in the center. (Bear in mind it is merely symbolic.)

What else could a human being do to achieve perfect control? Now, a good deal depends on application lags, delays, capacities, etc., so a brainy brain will make decisions based on the *rate* of deviation. See the thin-line arrangement at the left.

What more could the brain do? The foregoing suggests the answer: receive signals from a plurality of measuring elements in order to *anticipate* . . . but enough for a first lecture.—M. F. Behar



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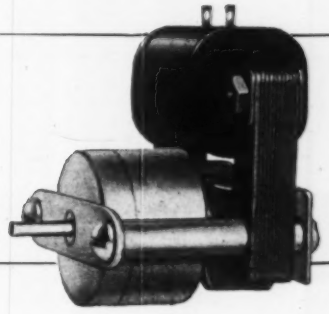

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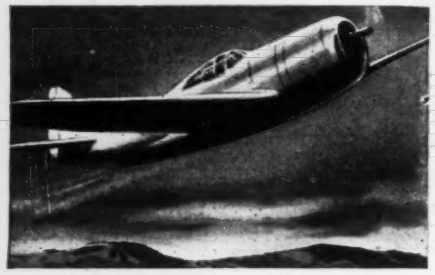

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Mechanized Titrations

Concluded from page 403

Operating Procedure. The analyzer is operated as follows:

(1) Turn on air supply and adjust pressure regulator valve until approx. 1″ water pressure is indicated on the manometer.

(2) Fill reservoir with 0.01 N silver nitrate (approx. 50 cc.).

(3) Turn on power switch. The burette will automatically fill itself and return the pen to zero. Until the START button is pressed, the burette will continue to refill itself should there be any leakage at the "drop" valve. Thus the titration will always start from a completely filled burette.

(4) Allow ten minutes for the tubes to become thermally stable and then press in the ZERO ADJ. knob (this shorts the electrometer leads), and adjust for zero electrical reading. Since the millivoltemeter is highly damped, adjust-

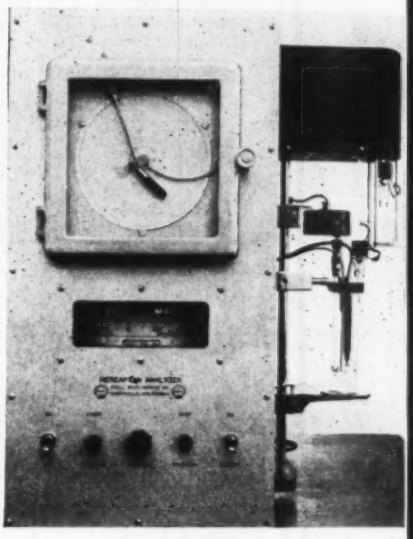

Fig. 3

ments must be made slowly to prevent overshooting. (*Note:* This zero point is not to be confused with the mechanical zero which is the normal rest position of the pointer and corresponds to +200 mv. on the scale.)

(5) Place 100 ml. of gasoline and 50 ml. of electrolyte (–0.1 N sodium acetate in isopropyl alcohol) in the beaker and place it in position on the titration stand. Start stirrer and press START button.

The sequence of events following the actuating of the START button is as follows: (Refer to Figs. 1 and 2.)

The drop valve L_2, through contacts 2 and 4 of relay A_2, opens within a few seconds and allows a drop of silver nitrate solution to fall into the titration beaker. Additional drops, controlled by the cam-operated Microswitch D_4, which is driven by Telechron motor M_3, fall at intervals of 7½ seconds. This gives sufficient time for equilibrium to be established. As each drop leaves the burette, the silver nitrate

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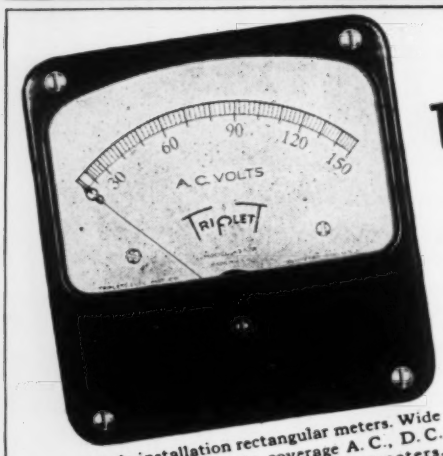

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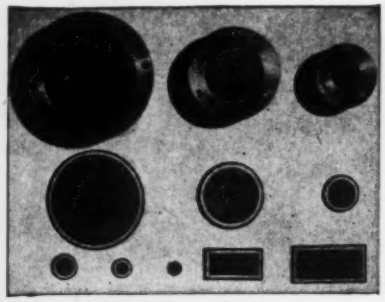

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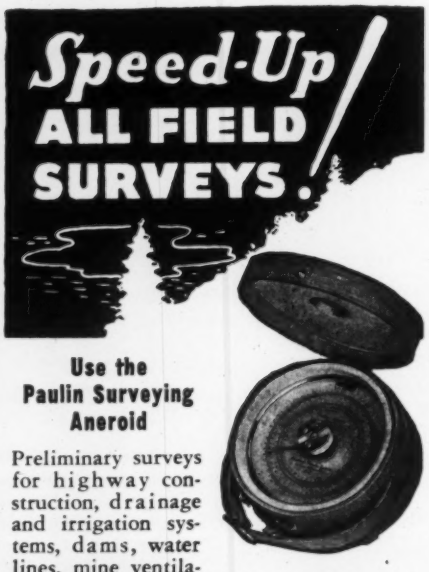

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meniscus drops away from the conta
B, energizing relay A_1, and throu
contact 3 of relay A_2 starts the mot
M_2. This drives contact B downwar
until it again contacts the silver n
trate and stops the motor. A corr
sponding proportional movement of th
pen follows each downward moveme
of point B through the connecting c
ble and cam.

As the titration progresses, the poin
er deflection of the millivoltmeter a
proaches the set end-point of −250 m
When the end-point is reached, the co
trol relay contact closes and energiz
relay A_2 which is locked-in by conta
1. Contact 4 of relay A_2 reverses th
direction of the motor which drive
contact B upward continuously and
full speed until the limit switch D
opened, setting the zero position
the chart and burette.

Contact 4 switches the vacuum-tub
relay circuit from the drop solenoi
L_2, to the fill solenoid L_1. The actio
of this circuit closes the fill valve eac
time the meniscus in the burette co
tacts point B during its upward trave
The filling rate from the reservoir i
greater than the upward speed of th
point B, which results in the fill valv
opening and closing at a rate just suff
cient to maintain the meniscus touchin
point B.

The circuit retains this mode of op
eration until the START button is actu
ated. The START button shorts the "up
limit switch which moves the contac
B a few thousandths of an inch higher
this opens limit switch D_2 and release
the lock-in connection of relay A_2. De
energizing relay A_2 allows contacts
2, 3 and 4 to drop into the titrating po
sition and the titration proceeds as pre
viously described. It should be note
that until the START button is actuate
the system remains on the refill cyc
and that the burette will keep itse
filled regardless of any leakage occu
ring through the drop valve.

The successful operation of the me
captan analyzer is dependent upon th
automatic burettes particularly th
magnetic valves, and too much empha
sis cannot be placed upon the necessit
of keeping the entire burette scrupu
lously clean, for the smallest partic
of foreign material on the seat of th
fill valve will cause appreciable leaka
leading to erroneous results. The us
of tapered ground joints simplifies di
assembly for cleaning.

To avoid the possibility of introdu
ing solid particles with the silver n
trate solution, it is advisable to fill th
reservoir through a filter funnel.

The electrodes should be cleaned onc
weekly. The silver should be lightl
sanded with fine sandpaper and the
wiped with a clean cloth. The glas
electrode should be washed with wate
or solvent and then carefully drie
with a clean cloth. After the electrode
are cleaned, at least one run will b
required before their surface condition

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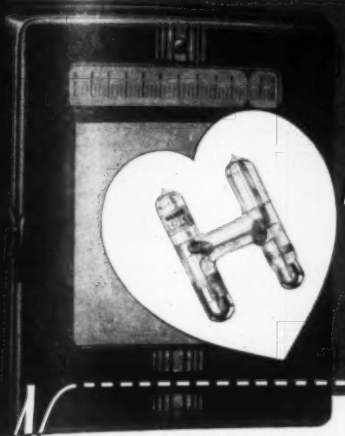

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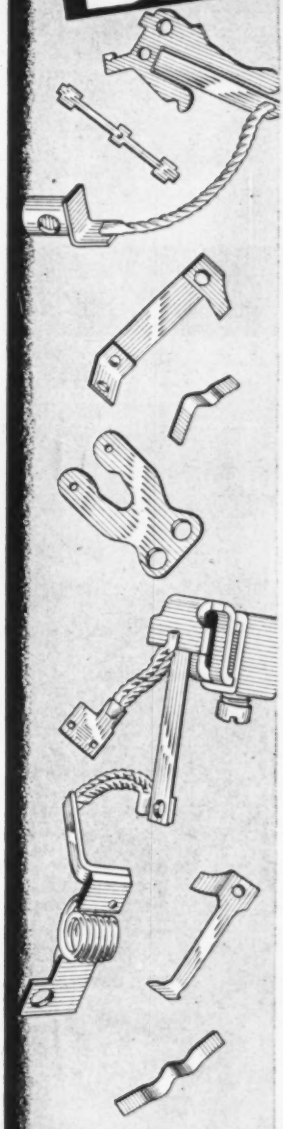

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are stabilized and reliable results obtained. When the instrument is not in operation, the electrodes may be immersed in the last sample run or in isopropyl alcohol.

The calibration of the chart is based on the use of gasoline of 0.75 specific gravity and an operating temperature of 25°C. For non-standard conditions the chart reading should be multiplied by the following expression:

$$\frac{0.75}{S} \times \frac{S' \text{ at } T°\text{C.}}{S' \text{ at } 25°\text{C.}} \times \frac{N}{0.01}$$

where S = specific gravity of the gasoline sample
S' = specific gravity of $AgNO_3$ solution
N = normality of $AgNO_3$ solution
T = actual operating temperature

Other Applications. Among other applications suggested for this automatic titration apparatus are the rapid titration of spent lubricating oils to determine their saponification numbers and for acidity in petroleum and related products that are soluble or partly soluble in benzene - isopropyl alcohol mixtures.

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New American Standards for Transformers, Regulators and Reactors Aid War Effort

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Of importance to the war effort in helping to conserve critical materials, expedite production and lower costs through production economies, these new standards also prevent misinterpretations between buyer and seller. They give the buyer a yardstick for measuring the merit of the apparatus he purchases and help him to eliminate special requirements. By specifying that apparatus shall be in accordance with American Standards, the purchaser is saved much effort in the preparation of detailed specifications and is assured of obtaining equipment best suited for the specific installation.

These standards, which have the advantage of criticisms and suggestions made for 18 months on a preliminary edition, supersede numerous other publications and constitute a veritable bible of information for manufacturers and users. The industry now has in a single book the most complete electrical standards yet published on transformers, regulators, reactors, and related induction apparatus together with other useful information on testing and operation.

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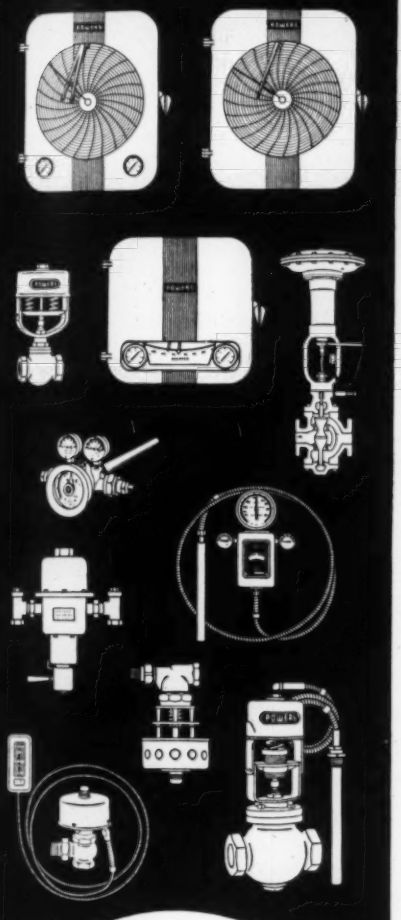

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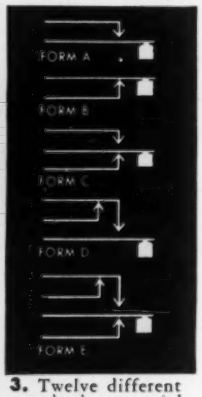

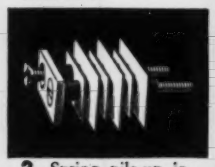

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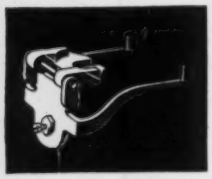

6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.

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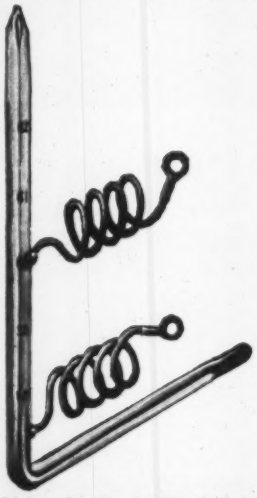

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For the first time in any industry standards, comprehensive guides for loading under various service conditions are given. Thus the standard rating becomes of less significance as a guide to the output but retains its importance to the purchaser as a measure of the amount of material in the transformer. The guides for loading transformers recognize that the loads permissible for a transformer vary over a wide range depending on the operating conditions, such as ambient temperature, cooling facilities, etc. Under low ambient conditions, safe continuous loads can be greater than the rating. Under all conditions short-time overloads can be carried, the amount depending on the time and previous loading.

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The ASA Sectional Committee on Transformers, which prepared the standards, includes representatives from various American standardizing bodies including the American Institute of Electrical Engineers, Electric Light and Power Group, National Electrical Manufacturers Association, Association of American Railroads, U. S. Department of Commerce and National Bureau of Standards. This committee, headed by V. M. Montsinger, Chairman, and E. B. Paxton, Secretary, will continue to take advantage of suggestions from the use of these standards and for changes and additions resulting plain to publish an addendum report once a year, to keep the standards up to date and continue their importance as a real reference work.

The American Standards for Transformers, Regulators and Reactors (Including Test Code and Guides for Operation) (C57.1, C57.2, C57.3-1942), complete in one volume, may be obtained from the American Standards Association, 29 West 39th Street, New York, at $1.25 per copy.

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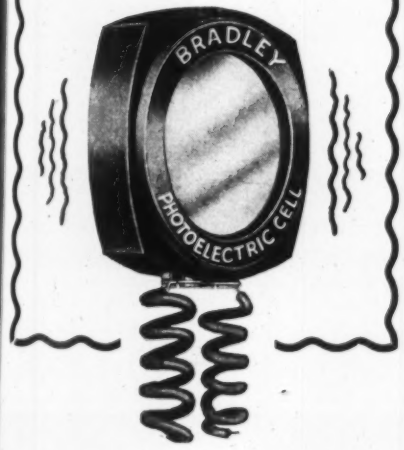

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Stop waste . . . Substitute mechanical precision for guesswork . . . Save precious material and man hours . . . Improve quality and increase production with reliable, **automatic** Stromberg Timing Instruments.

Ruggedly constructed for heavy service. Sealed to exclude dust and moisture. Not affected by temperature changes. Easily set for any time interval within the dial range. Makes or breaks an electrical contact at the end of each cycle. A glance tells the interval set, the time elapsed and time yet to run. During operation, the time interval cannot be altered. Dial ranges are available to fit any application.

The No. 55 Process Timer runs for the time interval set, makes and holds a contact until it is reset and restarted.

The No. 57 Automatic Repeating Timer makes a contact at the end of the interval set, automatically returns to zero and begins a new cycle—repeating this program until stopped or changed.

Use Stromberg Timers to ring signal bells, light signal lamps, start and stop electric motors, reverse drafts, open and close valves. Thousands are in use today in steel plants, tool industries, rubber processing plants and in baking, preserving, tanning, enameling, plating and heat treating processes.

Write us for complete information. Our engineers will be glad to study your problem and make recommendations without obligation to you.

No. 57 Automatic Repeating Timer

STROMBERG TIME CORPORATION
SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION
109 LAFAYETTE STREET NEW YORK, N. Y.

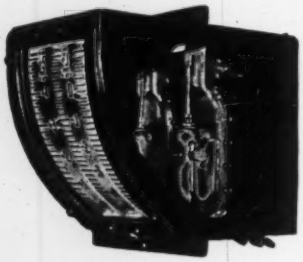
BAILEY METERS

METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-14

BAILEY METER • COMPANY •

1041 Ivanhoe Rd., Cleveland, Ohio

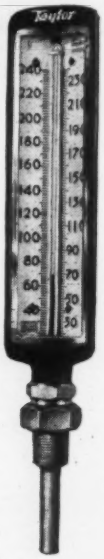
BAILEY METER COMPANY LTD., MONTREAL

The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

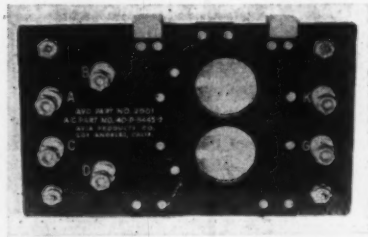
Industrial Thermometers

Motivated by a desire to save critical metals in war time, makers have designed, tested in the field, and are now introducing a one-piece industrial thermometer. One-piece case is shallower than conventional design, which makes it possible to see mercury column through a wider angle of vision. Chromium-plated bezel fits snugly into grooved case in such a way as to hold thick glass front securely against four wavy tension springs. These springs are fastened securely under scale by shakeproof screws. This construction is said to result in a dustproof, rattleproof and practically fumeproof thermometer; it can withstand vibration and severe shocks. It is said that these improvements are combined with durability, permanent accuracy and responsiveness to change in temperature. A saving of tons of critical bronze is effected by new construction. Makers announce further that the new instruments will be equipped with easy-reading "Binoc" tubing (see *Instruments*, Sept. 1935, page 247; Sept. 1940, page 243). They will be furnished in many combinations of straight and angle stems, with threaded or union connections, and in many standard temperature ranges, within the limits of −40°F. to +750°F. Standard scale lengths are 7″ and 9″. Scales are individually calibrated for each tube.—*Taylor Instrument Companies, Rochester, N. Y.*



Base Assembly Regulator

New Base Assembly Voltage Regulator that can be used wherever called for under Army Air Forces Specification 40D8445-2, is said to be used for aircraft, tanks, or auxiliary power units in conjunction with a voltage regulator. Exceptionally prompt delivery is assured by the manufacturer. If the stop nuts illustrated are not available, AN nuts and lock washers with A.A.F. approval will be supplied.—*Avia Products Co., 7266 Beverly Blvd., Los Angeles 36, California.*

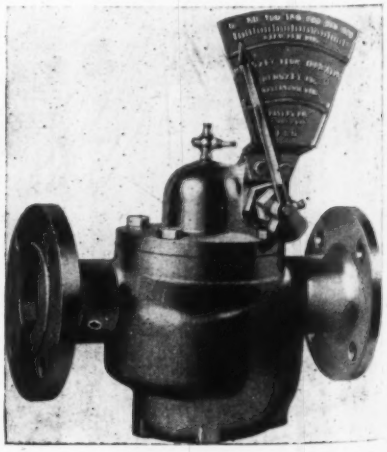


Oxygen Flow Indicator

New oxygen "Flow Indicating Meter" is a special model of the one described (with diagram and parts list) in *Instruments*, Jan. 1935, page 23. Scales are calibrated to read in liters of oxygen per minute. New flow indicator provides instantaneous readings, requires neither calculations not application of correction factors. Instruments are constructed entirely from metal. As did previous models, they utilize the variable-area principle of flow measurement: a floating piston is lifted by the incoming gas until its weight balances the pressure loss through the orifice area. At point of balance, flow rate may be read directly from pointer attached to piston. It is claimed that accuracy is "comparable to that of any accepted test meter." Indicator being of rugged construction, is not easily damaged. It is of simple design, easy to clean and maintain in accurate condition. Four sizes are available, with maximum flow capacities of 2, 5, 10 and 150 liters per minute, respectively.—*Pittsburgh Equitable Meter Co., 400 N. Lexington Ave., Pittsburgh, Pa.*

Liquid Flow Indicator

New Flow Indicator is a refined version of the one described (with diagram and parts list) in *Instruments*, Feb. 1941, page 31. Its three moving parts—plunger, lever-shaft and pointer—are of Monel metal. As did previous models, it utilizes variable-area



AS RECENTLY ANNOUNCED, *we are now building "Megger" instruments in this country, and are in production on the popular "Meg" and "Super-Meg" types. The acceptance accorded these new all-U. S.-made instruments has added to our already large backlog of orders, which we are now filling as rapidly as possible. Your orders for "Megger" instruments will be accepted according to priority ratings and with our assurance that delivery will follow as quickly as our further-expanding facilities will permit.*

FORESTALL electrical breakdowns... WITH THE "MEGGER" TESTER!

Now, more than ever, it is vital to hold electrical failures to a minimum. Periodic testing of the insulation of motors, generators, cables, signal-control and other electrical apparatus can save priceless time and protect irreplaceable equipment. Testing with a "Megger" instrument is only a matter of minutes, but it can reveal potential damage and save days of costly delay.

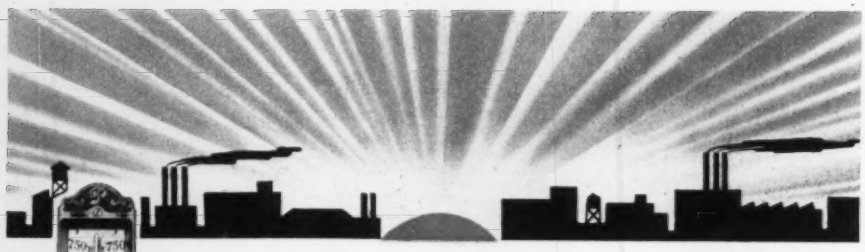
"Megger" insulation testers are completely self-contained—wholly independent of batteries. Simply connect to the equipment under test, turn the hand cranked generator and read insulation resistance directly by the pointer over the scale. Over 40 years of service in industry has proved the value of "Megger" Practice.

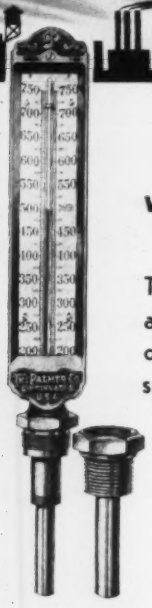
Write for any or all of the bulletins listed and a free copy of the Pocket Manual of "Megger" Practice, No. 1420-I.

BIDDLE BULLETINS

- Use of Hand-driven "Megger" Testers, Bulletin 1655-I.
- How to Test Insulation and Avoid Trouble in Electrical Equipment, Bulletin 1640-I.
- Various types of "Megger" Insulation Testers, Catalog 1685-I.
- Bulletin 1735-I on the New U. S.-made "Megger" Insulation Tester in plastic molded case.

JAMES G. BIDDLE CO. · 1211-13 ARCH STREET · PHILADELPHIA 7, PENNA.





Until the Light Shines Again

WE MUST KEEP ON MAKING THERMOMETERS FOR UNCLE SAM AND FOR VICTORY

These thermometers must be made to the same high standards for which Palmer Thermometers are famous because only GOOD thermometers will help to win the war more speedily.

In the meanwhile, REMEMBER Palmer Quality means:

1—Easy-reading "Red-Reading-Mercury"
2—Guaranteed permanent accuracy
3—Constructed for long life.

(Catalog sent on request)

THE PALMER COMPANY, Mfrs.

INDUSTRIAL, LABORATORY, DIAL & RECORDING THERMOMETERS

2511 Norwood Ave., Cincinnati, Norwood, O.—Canadian Plant: King & George Sts., Toronto

Have You Watches Which Need Repairing?

We Specialize in Repairing Factory Time-Study Watches.

Our fully equipped, modern watch repair department, which employs only expert mechanics, will accept the repairing of all types and makes of Factory Time-Study Production, Decimal, Split-Second and Complicated Timers, Stop-Watches, Chronographs and Repeaters.

All Timers are checked with Western Union Naval Observatory Time, and adjusted with scientific precision on our Western Electric Watchmaster Recorder (see illustration). An automatic chart record of accuracy is included with each Timer.

Repairs are fully guaranteed by us for one year against defective workmanship and material.

Send your Timers to Dept. I.M. for an estimate. No obligation on your part. Insure shipment to guarantee safe arrival.

JARDUR IMPORT CO., 874 Broadway, New York, N. Y.
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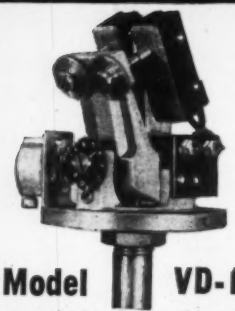
Manufacturers of Jardur Precision Aviation Accessories

BURLING
TEMPERATURE LIMIT SWITCHES



Model VD-11

Latest type double switch for temperatures up to 1200° F. Adjustable range 300-600 degrees. Easy-to-set dial pointer outside case. Makes possible:

1. Control of heating or cooling or both.
2. Control of temperature and giving either a high or low limit device.
3. Either two or three step control.
4. Floating control with reversing control motors.
5. Two or three speed control of auxiliary motors.

Size 3½" dia. x 4⅝" high

INSTRUMENTS ALSO BUILT TO SPECIFICATIONS

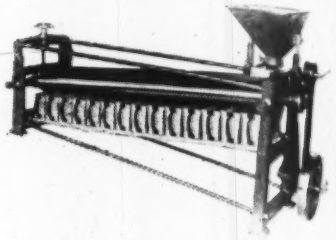
Send for Informative Bulletin

BURLING INSTRUMENT CO.
251C Springfield Ave.
Newark, N. J.

principle of flow measurement where average power actuating pointer is l times that in most flow indicators and in cates from zero flow to full capacity on unifomly-graduated scale. It is available seven sizes from ¾" to 4" pipe connecti from 10 g.p.m. to 600 g.p.m. maximum f capacity. Originally developed for indic ing flow of hot dirty blowdown from ste boilers, it is suitable for indicating fl of free-flowing liquids such as boiler f water, gasoline, light oils, etc.—*Hena Co., Watertown, Wis.*

Automatic Size Classifier

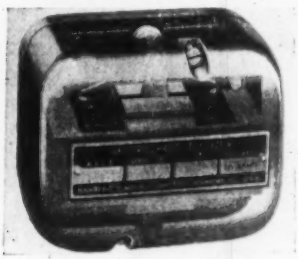
New "BC-50" classifying machine sor disk-shaped parts by means of adjustab divergent rollers and fixed slots, delive parts into fourteen removable pans. Adju



ment features permit automatic classific tion in size steps as small as 0.001". Ele trical vibrator also is adjustable. Overa dimensions, 8 ft. long, 2 ft. wide, 4½ f high.—*Barry Co., 9 South Clinton St., Ch cago, Ill.*

Motor-positioning Relay

New "Micropositioner" has been designe primarily for aircraft service. It is a polar ized d-c. voltage-sensitive relay, for remot positioning of control motors and control o air valves, engine cowling flaps, trim tab and similar aircraft installations. Contac tongue of Micropositioner is positioned b



means of a balanced armature. Effect o vibration is said to be reduced to a min mum. Entire operating mechanism is mount ed on a Bakelite base and enclosed in a transparent Lucite case: contact inspectio without removal of cover. Sensitivity is 0.1 volt, 0.002 amp.; weight 6 oz.: contac rating 0.5 amp. at 28 volts, non-inductiv load.—*Barber-Colman Co., Rockford, Ill.*

Half-wave Rectifier

New "N Type" rectifier of the half-wave type with characteristics said to have bee rendered permanently stable is added to the Emby instrument and relay selenium recti

fiers line. It is said that a special formin process has given this rectifier an unlimited life. Working temperature range extends from −70°C. to +75°C. and a negative tem perature coefficient is exhibited. All associ ated equipment, such as instruments, relays

with VARD precision Plug Gages

If you are manufacturing or are assembling units in which there are pipe connections threaded to the Army-Navy Specification, AN-GGG-P-363, you will need accurate pipe plug gages.

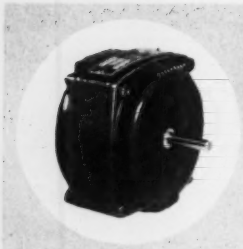
These VARD Pipe Plug Gages will quickly check the Major and Minor Diameter of internal threads, the thread form and truncation as well as lead and minimum length of threading.

VARD Pipe Plug Gages are made to American Gage Design standards and the Army-Navy Specification. They may be obtained in a full range of sizes 1/16th-inch to 6-inches diameter. All VARD Pipe Gages are made of selected tool steel, hardened, ground and finished to the specified tolerances.

VARD INC.

PASADENA, CALIFORNIA, U.S.A.

Special Taps • Snap Gages • Lathe Compounds • Dividing Machines • Aircraft Hydraulics • Aircraft Geared Parts • Course Plotters • Precision Ground Optical Lenses & Filters

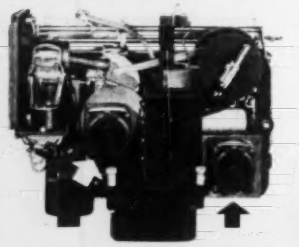


PRECISION MOTORS
for important instrument applications

The Bodine Type K Motor, only 2⅜" x 2⅜" x 1⅝", is probably the smallest distributed wound motor now manufactured. It possesses considerably more power than motors of clock-type construction, employs no permanent magnets, and does not decline in performance with age. Synchronous and non-synchronous types.

TYPICAL APPLICATION

C. J. Tagliabue "Celectray" precision pyrometer uses two.



Whenever motor-driven instruments require accuracy and precision in operation—as in many types of scientific and industrial apparatus—you'll find Bodine fractional horsepower motors. These motors are carefully manufactured of quality materials to meet uniformly high standards of accuracy. They are made in a wide range of sizes, with and without speed reducers, in all types of windings.

Many manufacturers have standardized on Bodine motors because they know they can depend on Bodine quality. Bodine has been supplying industry with precision electric motors for over 35 years. Bodine Electric Company, 2244 W. Ohio St., Chicago, 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

RUBICON PORTABLE PRECISION POTENTIOMETER

Available in a number of double-range combinations, such as 1 volt and .1 volt, 100 MV and 10 MV, also in pH ranges. Guaranteed accuracy .1%. *An outstanding value.*

Described in Bulletin 270 which also describes *Rubicon* High Precision Type B Laboratory Potentiometer.

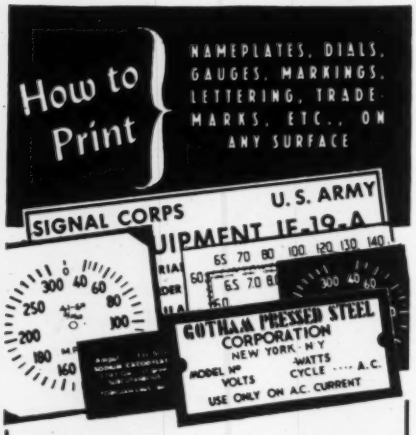
We also make galvanometers, colorimeters, permeameters, Wheatstone and Kelvin Bridges, resistance standards, coil testers, acronographs.

Descriptive bulletins available on request.

RUBICON COMPANY

Electrical Instrument Makers

Ridge Ave. at 35th St., Philadelphia, Pa.



1. Facilities for complete production—any quantity, 1 to 1,000,000.
2. MULTI-MARK Screens made up for any design; reproductions may be made directly on article without machines; complete directions furnished.

We're helping companies engaged in all types of war production . . . if you have a marking problem of any nature, ask us for information . . . We've had experience with all surfaces, all finishes, all government requirements.

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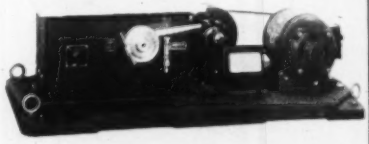
COLONIAL PROCESS SUPPLY CORP.

136 West 23rd St., NEW YORK

etc. have positive temperature coefficie with resulting compensation when used w selenium rectifiers. The "N-2" consists two rectifying elements ½" in diameter sembled in a tubular plastic case ¼" a is rated 10 volts a.c. The 20-volt a.c. w therefore, consist of four rectifying e ments; and a rectifier rated 40 volts a will consist of a rectifier stack of eight e ments. D-c. rating for continuous load 1 ma; for instantaneous load, 3 ma. I pedance in the forward direction is of t order 1000 ohms. Impedance in reverse rection is of the order 1 megohm per pla All units are hermetically sealed with co pound so that assembly is independent atmospheric changes and impervious moisture. Two soldering terminals are pr vided. — *Selenium Corporation of Americ 1800 W. Pico, Los Angeles, Calif.*

Vibration Fatigue Testing Machine

New "Model 100" is added to make line of vibration fatigue testing machine (see *Instruments*, March 1943, page 162) will subject parts or assemblies up to 1



lbs. to vibration fatigue tests. Table has a area of 15" × 18" and has 115 tapped hole Table movement is horizontal. Frequency adjustable while machine is running, fro 10 to 60 cycles per second (600 to 3,600 v brations per minute) and is indicated on a electric tachometer. Displacement, from to 0.125" (adjustable) is said to cover fu range encountered by parts subjected t vibration in actual service. Maximum acce eration capacity is 23*g*. Base area 24" 42"; weight 550 lbs. A 1½ h. p. motor sup plies power. Eye-bolts in base permit han dling with a shop hoist or crane.—*All Ameri can Tool & Mfg. Co., 1006 W. Fullerto Ave., Chicago, Ill.*

Industrial Rectifiers

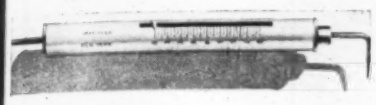
New "Rectrodyne" rectifier is claimed t have many advantages over generator set for general industrial use, can be furnished in stationary or portable models, in capac

ities up to 4,000 watts; provides smooth d-c power for aircraft testing, operating d-c motors, charging industrial and military batteries, etc. D-c. voltages of 6, 12, 24, 3 and 48 volts can be furnished. A dual volt age feature is available which permits dou bling current at half voltage by means of a

eries-parall[illegible] switch. Output control is by rotary tap switch in primary circuit operated by a knob on front panel. The "Heavy-uty Rectodyne" is claimed to have intermittent overload capacities of as high as 00%. Unit incorporates dry-disk type of ectifying element capable of withstanding igh ambient temperatures. Size (16" × 16" 29") makes unit suited for test floors and r fields. Silent long-life operation is said be assured, as only moving part is a entilating fan driven by a fractional h.p. otor requiring no starting mechanism.—*cColpin-Christie Corp., Ltd., 4920 South igueroa St., Los Angeles, Calif.*

Push-pull Gages

New "Push-pull Gauges" are for the easurement of tensions, pressures, mechanical reactions, breaking strains, "and other ght forces from ½ gram to 100 pounds."



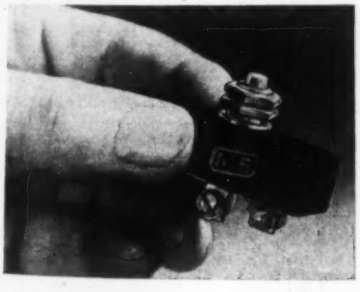
They can be used for testing spring characteristics, measuring relay pull, checking o push-pull button switches, adjusting operation of spring-loaded mechanisms, determining the breaking strength of fibres, and so on. It is said that inexperienced workers an duplicate or improve upon results obtained by skilled workers depending upon "feel." Being manufactured in standard models, they are said to be sufficiently low n cost to permit use in quantity as shop est equipment or as standard equipment or field test kits.—*John Chatillon & Sons, 5 Cliff St., New York City.*

Bimetal for Circuit Breakers, etc.

New "No. 6850" thermostatic bimetal combines high electrical resistance with a high thermal deflection rate. Resistivity is given as 850 ohms per circular mil foot, or 668 ohms per square mil foot, at room temperature. Deflection rate is practically uniform between 0°F. and 400°F.; slightly lower above and below those temperatures. Operating characteristics are said to remain constant at temperatures as low as —100°F. New bimetal is intended primarily for thermostatic resistors which operate as a result of the heating effect of the current. Applications range from flashers to motor overload protection; including particularly the newer circuit breaker designs.—*W. M. Chace Co., 1609 Beard Ave., Detroit, Mich.*

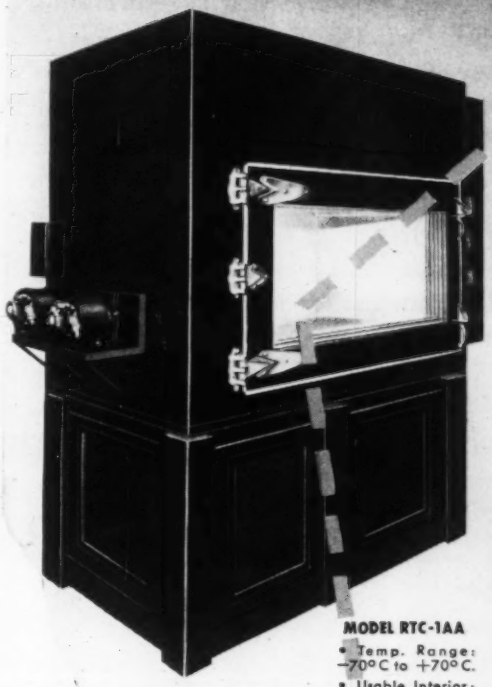
Tiniest "Micro Switch"

New "Peanut Micro Switch," now in full scale production, is tiniest of maker's line of small precision switches. It is said to be more rugged, lighter and more resistant to



vibration than the larger models. It has a higher electrical rating. The "Peanut" is available both with and without an enclosing case. When used without case, actuating movement can be applied anywhere over a large portion of the upper spring. With

QUICK "SEASONING"
FOR NEW INSTRUMENTS



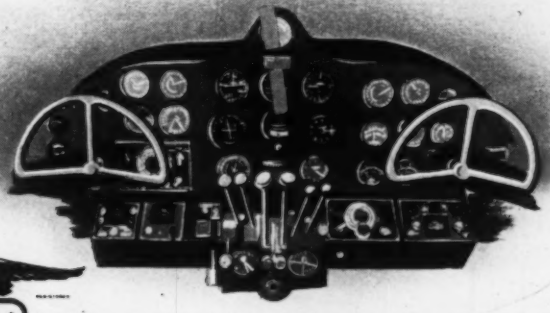
MODEL RTC-1AA
• Temp. Range: −70°C to +70°C.
• Usable Interior: 25.7 cu. ft.

AMCOIL
means Accuracy in high and low temperature performance pre-testing.

New instruments can be tested rapidly under service conditions; scientifically "seasoned" for performance in sub-zero cold or blistering heat. AMCOIL Test Chambers make this possible. With the correct AMCOIL unit, instrument makers and instrument users alike are assured compliance with atmospheric specifications.

AMCOIL means accuracy when you must pre-test delicate aircraft instruments, electronic devices and other precision equipment. In the Model RTC-1AA temperatures are thermostatically controlled in a range from −70° C. to +70° C. (−95° F. to +160° F.). The usable interior of this cabinet is 25.7 cubic feet. Five sealed and dehydrated panels of glass in the door give clear observation of products under test.

In addition to temperature test chambers with either mechanical or dry ice refrigeration, AMCOIL units are furnished for humidity testing and altitude testing. Ask an AMCOIL Engineer to help you by recommending the correct equipment for war-time pre-testing of your instruments.



AMCOIL
AMERICAN COILS CO.
25-27 LEXINGTON STREET • NEWARK, N. J.
4020

Ideas Incorporated

When the soldiers and sailors of World War II return to civilian life they will bring with them a new respect for the importance and value of precise instrumentation. The same will be true of the legions of women who presently are mastering the intricacies of industrial mechanics.

After victory, these mechanically-minded millions will be eager prospects for a wide variety of scientific equipment. If you plan to cater to this postwar market and your device is optical in character, or involves precision in control or operation, perhaps our knowledge and experience may be helpfully incorporated in your product. Your inquiries are invited now.

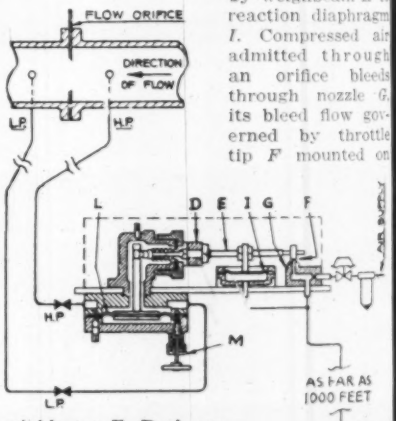
KOLLMORGEN OPTICAL CORP.
4 Franklin Avenue **Brooklyn, N. Y.**

Bakelite case a convenient stem mountin is provided. Construction is said to provid inherent overtravel beyond the point o operation great enough for most uses. Othe features: (1) Contact gaps up to 0.08 which can be varied in manufacture, wid gap especially valuable on d-c. loads; (2 Pure silver (99.95%) contacts, formed wit a knurled surface to provide high unit co tact pressure for low-voltage application and reduce danger of dirt in contacts whe an enclosing case is not used. "Peanut Mi cro Switch" is suitable for uses where com bination of extremely low operating forc and super-fast action is not so important —*Micro Switch Corp., Freeport, Ill.*

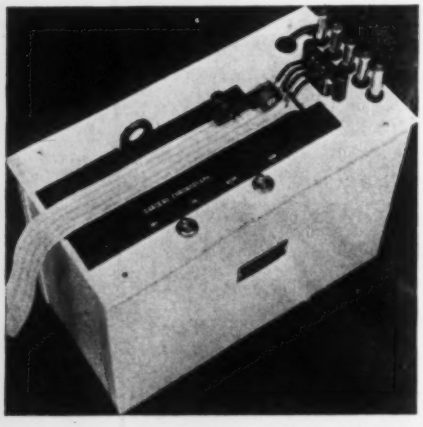
Pneumatic Differential-pressure Telemetering System

New Pneumatic Differential Pressur Transmitter, for measuring flow and level is expected to find numerous applications in chemical plants, oil refineries and othe process industries where fire and explosion hazards are present because it obviates the need of running long lines containing poi sonous or explosive products. It converts a differential pressure, such as produced by

flow of fluid through an orifice, or by liquid level in a vessel, into an air pressure which varies proportionally with the differential pressure. Although announced now, it has had two years of field testing, results of which enable makers to make the following statement: "Performances . . . show that the accuracy of this force-balance method of measurement is higher than can be secured by any other method, the Company guaranteeing transmitting pressure *vs.* measured differential within 0.5% of meter range." *Operating Principle.*—Differential pressure is exerted on differential diaphragm *L*. Force produced is transmitted by weighbeam *E* to reaction diaphragm *I*. Compressed air admitted through an orifice bleeds through nozzle *G*, its bleed flow governed by throttle tip *F* mounted on



weighbeam *E*. Back pressure on nozzle *G* is conducted to reaction diaphragm *I*. Any motion of throttle tip *F* will therefore produce variations in pressure in *I* directly proportional to changes in force produced by diaphragm *L*. Forces times lever-arms are thus balanced as in balancing an ordinary beam scale and a true null-method is utilized. Pressure in *I* is a measure of differential-pressure across *L* and may be transmitted by means of ¼" tubing



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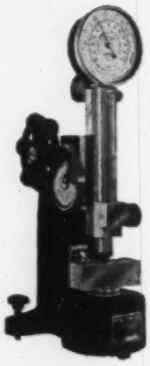

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•

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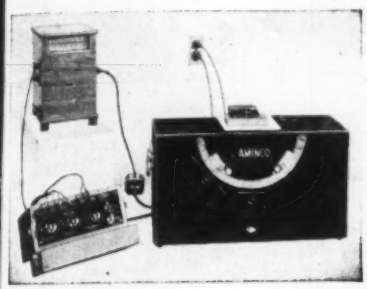
a receiving instrument at any distance to 1000 ft. *Responsiveness.*—When a receiving instrument was installed adjacent the transmitter, flow changes were shown most instantly. With 500 ft. of ¼" O.D. bing, full value of change registered on a epublic receiver in 15 seconds. (This is verall lag of system, not merely transmison lag.) *Sensitivity.*—Hysteresis loop is s than 0.05%. Company reports that ef- t of ambient temperature variations on curacy of transmitter is negligible; and at normal frequencies of vibration pres- t in industrial and processing plants do t affect the devices. *Ranges.*—From 0.9" 25" of water differential for working ressures up to 10 lbs./in.²; 7" to 50" of ater for working pressures up to 25 lbs./ .²; and 13" to 800" of water for working ressures up to 600 lbs./in.². Ranges are id to be easily changed in the field with a inimum substitution of parts. Company n provide special heads for pressures up 2000 lbs./in.².—*Republic Flow Meters Co., 10 Diversey Parkway, Chicago, Ill.*

Glossmeter

New Aminco-Scott Glossmeter (Goniotometer) measures high, medium and w gloss (from zero to 100%) of plane rfaces of materials over 2⅛" × 3" in size,



uch as paint finishes, enamels, lacquers, etals, wood, paper, plastics, glass, etc. Reults are in terms of the I.C.I. Normal Obrver and I.C.I. Illuminant C. The kinds of loss (relative apparent reflectance) measred with this instrument are specular gloss, ontrast gloss, distinctness-of-image gloss, bsence-of-bloom gloss, and many other opcal properties of surfaces of all kinds. It especially useful for A.S.T.M. method 523 for measuring specular gloss of paint nishes. Some suggested supplementary ses: measurement of hiding power of deosited finishes, cleansing power of soaps nd detergents, relative apparent reflectance f plane surfaces for obtaining Munsell alue, index of refraction, resistance of surces to abrasion, weathering, wear, etc., nd measurement of glare. Illumination is djustable from −30° to +70° from the ormal. Receptor is adjustable from +30 egrees to −70° from the normal. Angles ay be read to 1 minute of arc. Measureents of relative apparent reflectance from ero to 100% (in steps of 0.01%) can be ade. Measurements can be made rapidly: complete gloss curve of a high-gloss samle can be obtained in approx. 30 minutes. nstrument has sufficient sensitivity and ide range to measure relative apparent reectance from high gloss to flat gloss without the use of neutral filters, wedges, etc. It perates on 110-120 volts 60 cycles (conrolled frequency) single-phase a-c., and is naffected by fluctuations in line voltage. It eed not be operated in a darkened room. o upkeep cost except infrequent renewal f the lamp. Instrument comprises four ain components: (1) goniophotometer; 2) reference plate and sample holder; (3) ontrol and measuring unit; (4) galvanomter. A standard glass reference plate is upplied. Entire outfit weighs approx. 55 s.—*American Instrument Co., 8010 Georgia ve., Silver Spring, Md.*

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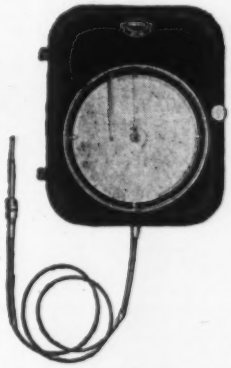
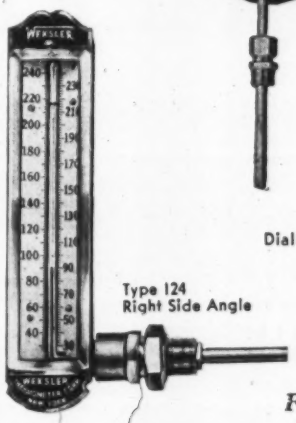
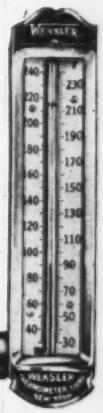


Dial and Recording Thermometers



Type 124 Right Side Angle

Type 125 Left Side Angle



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Weksler Thermometer Corporation

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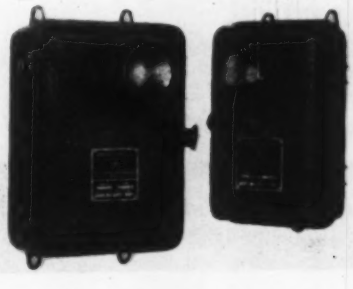
Quarter-mile-range Infra-red Photoelectric Protection System

New photoelectric protection system projects a fence of invisible infra-red light over distances as great as 1500 feet and gives local or central-station alarm if an intruder enters protected area. Designed to meet government requirements, equipment is said to have an operating range longer than that of any other photoelectric system and to be especially suited to protection of harbors, yards, docks, industrial properties, airports and similar large areas. In operation, light source "Type L60M" is aligned with receiver "Type A30M" to which it focuses a modulated beam of infra-red radiation. It is said that Type A30M responds only to the modulation frequency radiated by the source, is not affected by other artificial light or by daylight, permits extreme sensitivity and enables the equipment to function over a greater range than previously possible with photoelectric controls, and at the same time guarantees complete stability of operation. (If invisible infra-red radiation is not required, operating range of system exceeds 2000 feet.) Within light source Type L60M, a fan driven by a gearless



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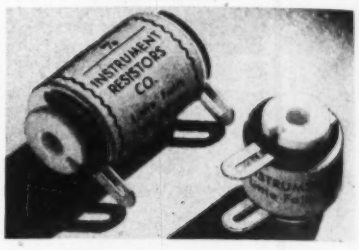
brushless motor serves as a light chopper t produce rapidly fluctuating light of the de sired frequency, and also cools the heavy duty lamp, assuring long life. Once th beam of invisible radiation projected to re ceiver Type A30M is momentarily broke the alarm circuit latches in operation. A additional safety feature is that either pow er or tube failure will cause the alarm cir cuit to operate as though the light beam had been broken. Receiver Type A30M an Light Source Type L60M are built for un limited service-free operation, furnished in weather-proof housings. Supplied with thes units is an auxiliary latching relay wit reset button. Equipment is designed for op eration on 105 to 125 volts a.c.—*Photo switch Inc., 77 Broadway, Cambridge, Mass*

Instrument Resistors

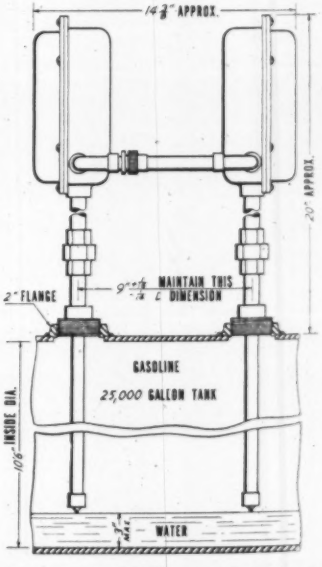
New "Type P-2" and "Type P-4" slotted terminal resistors are designed to meet com plex and intricate integrating requirements of precision apparatus where available are



is minimal and weight factor important. "Type P-2" has 0.5-watt rating, maximum resistance of 500,000 ohms, length $\frac{1}{2}$" diameter $\frac{9}{16}$". "Type P-4" has 1-watt rating maximum resistance of one megohm, is 1" long and $\frac{5}{8}$" in diameter. Terminal on both types are 0.025 hot tinned copper, slotted to take stranded or solid wire. Mounting is permitted by No. 6 holes through centers of bobbins. These resistors are said to find ex tensive use in various Army, Navy and Air Corps applications. — *Instrument Resistors Co., Little Falls, N. J.*

Water Detector Lock

Primary purpose of new "Wayne Water Detector Lock" is to prevent delivery of water into fuel tanks of aircraft being re fueled. (Water in gasoline of planes oper-

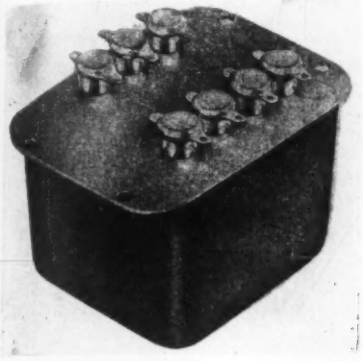


ating at high altitudes or in cold climates may freeze and cause stoppage of fuel flow.) Unit is a probe-actuated relay, with relay contacts connecting to magnetic starter of

gasoline-dispensing pump motor. When two Water Detectors are used, they are connected in series. Electron-tube equipment is assembled in a weather-proof cast-iron housing mounted on probe pipe which extends down into tank, terminating 3" above bottom of tank. When accumulating water reaches tube end, control operates to shut off pump. (Then water must be pumped from tank by suitable means before pump can be operated again.) Operation is on the same 3-phase 220-volt power source that serves the gasoline pump.—*Wayne Pump Co., Fort Wayne, Ind.*

Hermetically-sealed Transformer

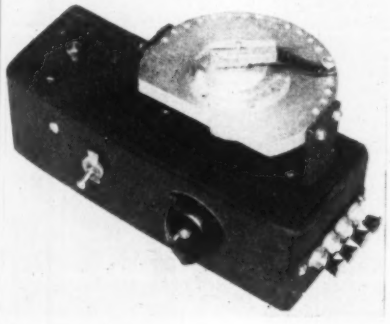
New moisture- and dust-proof transformers, said to meet all Navy and other specifications for hermetic sealing, use glass or porcelain insulators with metal bands. Insu-



lators are soldered into transformer case which is of cold drawn copper-plated steel and thus become an integral part of the case. "Vac-sealing" impregnation process is used, said to assure absolute impregnation without solvents or other deleterious material present inside the coil. Maker states that these new transformers may be quickly produced in any desired size or capacity to customer's specification. — *Peerless Electrical Products, 6920 McKinley Ave., Los Angeles, 1, Calif.*

Aircraft Autosyn Tester

New "Model 7 Autosyn Voltage Calibrator and Polarity Indicator," developed for use in manufacture and production testings of aircraft Autosyn indicating motors, may



also be used by military inspection stations and repair depots. To operate Model 7, insert the Autosyn motor in the frame; no clamps are required. All fits are held to 0.001". Positioning arm is then slipped over rotor shaft which ordinarily receives indicating pointer. To check calibration, positioning arm is set at 90° or center scale by letting spring arm snap into position. Unit is then connected to a vacuum-tube voltmeter and a source of 400-cycle power. The standard Autosyn, an integral part of the instrument, is then rotated by means of a knurled thumb screw until vacuum-tube

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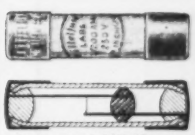

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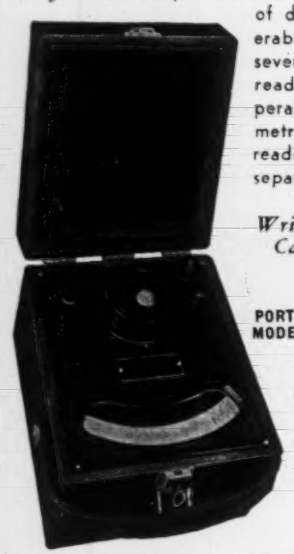
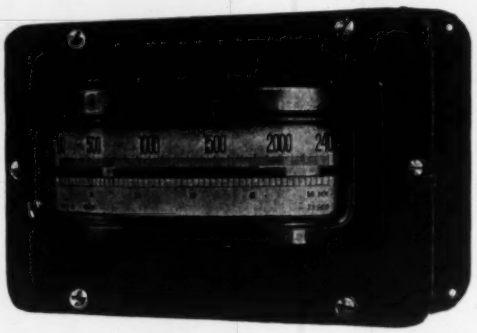


PORTABLE MODEL P-1



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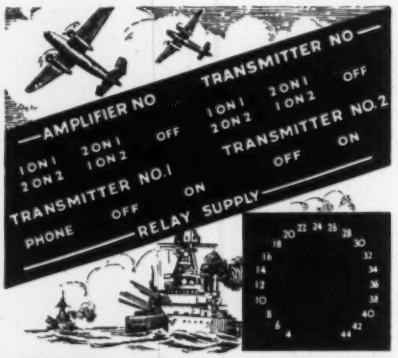

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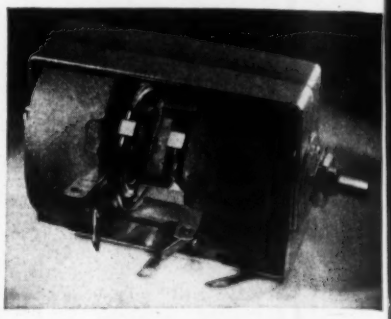
voltmeter reads zero. To check calibration lift positioning arm from center scale position and move clockwise or counter-clockwise one position. Each position from center is equal to 10° with an accuracy of ±3′; vacuum-tube voltmeter will then read voltage deviation from standard and can be checked progressively every 10° after balance to zero is made. This type of test is fool-proof and can be made by semi-skilled personnel. Unit is furnished with or without power supply and VT voltmeter. Dimensions: 10″ long, 6″ deep, 3″ high; weight 6 lbs. All pin positioning tolerances are held to ±0.0002″.—*Television Products Co., 6533 Olmsted Ave., Chicago, Ill.*

Tandem Power Rheostats

New tandem power rheostat assemblies of two or more sections are made up of two 25-watt or two 50-watt rheostats rigidly coupled together and held in a metal cradle.



Usual one-hole mounting and locking-projection features are retained. Individual rheostats can be of any standard resistance value, taper, tap and hop-off, and all units go through same degree of rotation as single shaft is turned. Units are fully insulated from one another and from ground. Because of wide choice of resistance values and other factors, new assemblies are necessarily made only on special order.—*Clarostat Mfg. Co., 285 N. 6th St., Brooklyn, N. Y.*

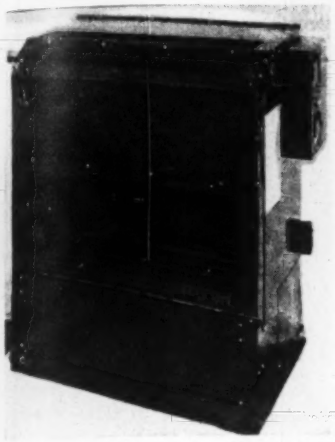
Humidity Test Chamber

New "Amcoil" low- and high-temperature test chamber, Model RTC-1H, has maker's standard refrigeration equipment (see description, *Instruments*, Sept. 1942, page 385) and, in addition, a new attachment for humidity control. Standard humidity range is ambient to 140°F.; ambient to 90% relative. Special adaptation can be made for humidities below ambient if requirements are known. Overall dimensions 95″ W. × 91″ H. × 42″ D.; interior (usable space) 52″ W. × 27½″ H. × 30″ D.; 25.9 cubic feet. New model is said to afford an unusu-

ally fast rate of temperature and humidity change. Its temperature range is —55°C. to +70°C. (−67°F. to +160°F.). Other features include use of two-stage Freon condensing unit, and positive forced air circulation that can be varied in volume. Observation door has five sealed and dehydrated panels of glass, 46" × 21½". Steel frame door has a clear opening 51½" × 26½".—*American Coils Co., 25-27 Lexington St., Newark, N. J.*

Instrument-shop Air Conditioner

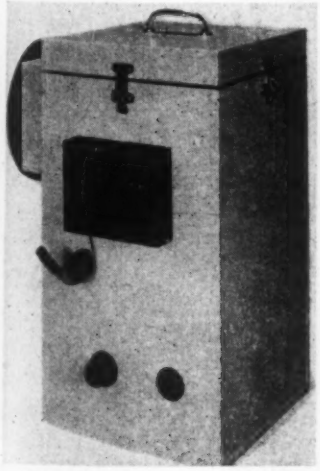
New air conditioner was specially developed for Army Air Forces' portable instrument repair shops which are big enough for



three men to work in but small enough to go in a cargo plane, cargo glider, or to fit in the body of an Army truck. Portable repair rooms of this type, made by the Herman Body Co. of St. Louis, are equipped with air conditioner pictured—a special adaptation of "Room Weathermaker," providing enough outside air into the repair rooms to insure adequate ventilation. This air is double-filtered of dust and excessive moisture is removed by a one-ton refrigeration unit which also cools the air to reduce perspiration on hands of workers. (Perspiration corrodes parts handled; high humidity rusts steel parts.) For winter heating a gasoline-fired heater, made by Hunter & Co. of Cleveland, is built into the air conditioner. Thus, complete functions of air conditioning are in one self-contained unit. —*Carrier Corp., Syracuse, N. Y.*

Cooling Unit for Separately-enclosed Test Specimens

New "Sub-zero Cooler" is designed to cool specimen under test to any desired temperature from 165°F. to −100°F. It is portable and arranged for attachment to



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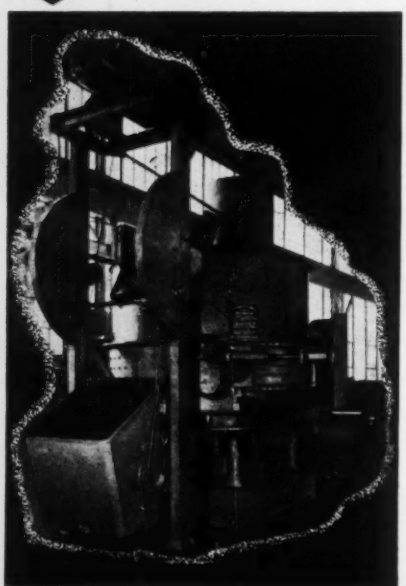

The R. W. CRAMER COMPANY, Inc.
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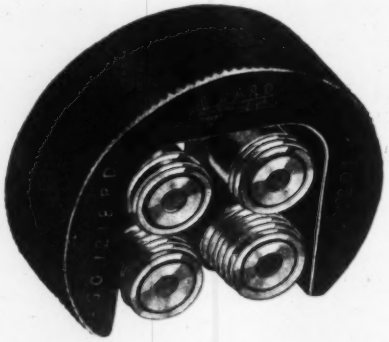
small enclosures built about the specimen under test located in the testing machine. It makes use of CO_2 as a refrigerant. Enclosure surrounding test sample can be built up locally to suit testing equipment in which sample is located. Dry ice compartment contains 50 lbs. of broken dry ice, is insulated with 2" of Foamglas, is lined on the inside with metal and trimmed on the outside with ¼" Masonite. Temperature is controlled by means of a United Electric controller which starts and stops blower motor. Rate of cooling is controlled manually by a damper in blower discharge. A small electric heater permits use of this equipment for temperatures higher than ambient, operates on 110-volt, single-phase circuit, is commanded by the temperature controller, the bulb of which is located in the re-circulated air duct and controls the temperature of air returned from the enclosure. Unit is driven by a motor, can be plugged into any 120-volt receptacle, consumes 650 watts. Dimensions 16½" × 16½" × 31"; weight 140 lbs.—*Tenney Engineering, Inc., 8 Elm St., Montclair, N. J.*

Thread Snap Gages

New "Vard Roll OC" thread snap gages are designed for checking P.D. and lead of "number series" screw threads to specified tolerances. Their small size and light weight,



it is said, make them "easier and faster to use than other means of checking screw threads which are on the market today." These gages are visual type as well as feeler type gages and are therefore, it is said, a surer means of inspection than those limited to feel alone. Snap test feature, in place of ordinary screw-on ring gage, saves time. Wear is said to have been minimized by good design and proper tempering of gaging surfaces. Adjustment feature is said to save frequent replacement costs. These new small roll thread "OC" snap gages run from No. 2-64NF to No. 14-20 NS.—*Vard Inc., 2981 E. Colorado Blvd., Pasadena, Calif.*

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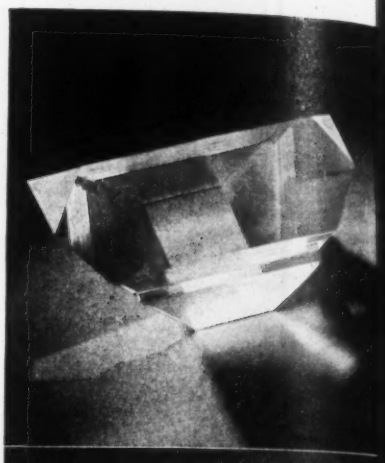
MAKE DEMOCRACY LIVE!

WANTED

INSTRUMENT DEVELOPMENT ENGINEER

Experience in design and production of industrial instruments with close tolerances required. Experience with engine indicators, manometers or similar instruments desirable. State education, experience and qualifications. Trill Indicator Company, 7000 Bennett Street, Pittsburgh, Pa.



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Illustrated above is a roof prism, the most accurate of all optical parts, used in military instruments for our armed forces . . . Roof prisms are being made by a number of manufacturers by methods first developed at The Perkin-Elmer Corporation . . . and gladly shared in the interest of winning the war.

The Perkin-Elmer Corporation
GLENBROOK, CONN.

★Another control problem—the kind Clarostat engineers like—came in recently. Specifically: a tandem assembly comprising dual 50-watt power rheostats and dual 3-watt wire-wound potentiometers; the latter insulated from shaft and ground for 2000-volt breakdown test; four units to have the same degree of rotation. In a hurry, of course; first a sample; then production running into large figures.

Clarostat engineers worked out the assembly here shown from standard units and parts, again demonstrating how time, money and effort are saved by the ingenious adaptation of the Clarostat wide choice of standard units and parts.

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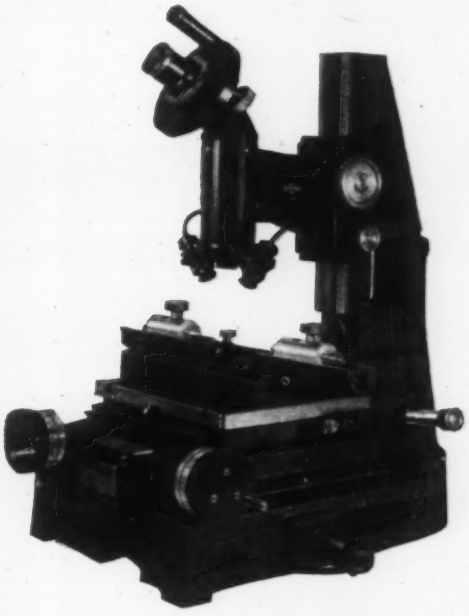

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Foremost among our precision optical measuring instruments, the Toolmaker Microscope is used in constantly increasing numbers in our nation's war industries for applications requiring length, coordinate, and angle measurements of high accuracy.

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INSTRUMENT MAN

experienced with instruments for recording and controlling flows, pressures, temperatures, levels, etc. Permanent position with large pulp and paper mill located in southeast coastal area, $1.25 per hour, 48 hour week, with time and one-half for over 40 hours. Vacation with pay. Moving expenses allowed. Give full details as to present status and experience. Those now engaged at highest skill in essential plants cannot be considered. Box 83, Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, Pa.

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Electrical Engineer—to work on and with Indicating Electrical Instruments. Experience on any kind of electrical instruments will be very helpful.

Allied experience, however, with engineering or production engineering on other small electrical parts may give you sufficient background.

If you are interested, we will be very glad to know your qualifications.

Write the Box Number below, in detail. Every inquiry will be answered. Box 84, Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, Pa.

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This aircraft instrument housing—Step No. 94 for a famous maker of war planes—looks like one piece. But it's actually five pieces! Five pieces of aluminum formed and welded, machined, finished—to limits .005. Isn't there a step in *your* production cycle where our "Packaged Production" would be a big help? You'll get 54 years of exceptional experience in Metal Fabrications: Precision Machine Work: Electrical & Mechanical Assemblies. Also, carefully organized operational methods to relieve you of all production responsibilities on an entire product—or a single part. Avoid production headaches and inquire if our prior commitments will "Let Lewyt Do It."
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Instrument Societies

MELBOURNE (AUSTRALIA)

In recent years an increasing interest has been shown in industrial measuring and control instruments. Engineering and scientific institutes publish in their Proceedings papers dealing with instruments, and there is a general demand for information regarding methods of measurement and what instruments are commercially available.

Steps are now being taken in Melbourne to form a Society to bring together those interested in these problems, and to make available as much information as possible regarding new developments. It is to be known as "The Society of Instrument Technology." Such Societies were started in the U.S.A. within recent years and have been very successful. Membership will be open to all reputable persons, and the object of the Society will be solely to improve knowledge, so that the constitution and organization will be as simple as possible.

A preliminary meeting will be held about August to adopt a constitution and arrange to launch the Society. This preliminary meeting will be attended by delegates from the various technical institutes, some of which have already signified their approval of the proposal. This meeting may also be attended by a representative of the instruments trade. Any technical society or institute in Victoria, or any instrument firm, who desires to have a voice in the preliminary discussions is invited to address an inquiry to the Society at 219 William Street, Melbourne. (Telephone MU4816).

NEW YORK

Fifty members attended the June 29, 1943 meeting, which took place after the customary dinner at Churchill's Restaurant. Our speaker was Mr. R. J. Kryter, Vice President of Esterline-Angus Co. Mr. Kryter's subject was "Machines, Men and Measurements." In his talk he reviewed the application of recorders to trouble-shooting, time studies, measurements of strain, temperature, pressure, electric energy, hydraulics, electronics, and blood pressures. The speaker carried the subject across to his listeners with excellent continuity. A lively question period followed the speaker's formal discussion. —BOB FARNHAM

PHILADELPHIA

Philadelphia closed its Spring and Summer session on June 16 with a bang-up meeting having 110 members in attendance, with 48 at the dinner.

Our Mr. Kermit Fisher's talk, "Rotameters and Their Secrets," fitted the occasion. For secrets they were—such as metering float design, heat treating, superfinishing of the glass metering tubes and high and low pressure applications. His talk was illustrated with slides.

To make one feel better in these days of gasoline rationing, Mr. Fisher mentioned the fact that the R.A.F. had made extensive flight tests of bomber squadrons over a period of time—one group using fuel flow meters, and the other group without meters, and that fuel savings ran to the order of 30% or better. One can see where a small Rotameter can mean bigger and better bombing missions to blast the Axis.

The meeting was followed with an old-fashioned suds and free lunch chin fest.
—GEORGE HAMMER

City, Society and Secretary		
Atlanta	Georgia Society for Measurement & Control	D. D. Beach, P.O. Box 4569, Atlanta, Ga.
Baltimore	Baltimore Industrial Instrumentation Society	Fred Pullen, Bethlehem Steel Co., Sparrows Point, Md.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.
Newark	New Jersey Society for Measurement & Control	R. F. Robey, 409 Orange Ave., Cranford, N. J.
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St., Calumet City, Ill.
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, 712 Otis Bldg., Phila., Pa.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.

Date	Place	Subject	Speaker
Oct. 5(C)	Public Service Terminal Restaurant	Application of Null Principle	C. B. Moore, Pres. Moore Products Co., Philadelphia

(C)Dinner at 7, meeting at 8.

Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on this page.

K-206 **Maximum Accuracy in Noise Measurements.** The May 1943 issue of the General Radio Co. contains Part 8 of "The Noise Primer." General Radio Co., 30 State St., Cambridge A, Mass.

K-207 **Hook-on Volt-Ammeter.** GEA 2950C, 8" × 10", 8 pages describes this instrument which permits measurements without cutting of conductors and without the use of additional equipment. General Electric Co., Schenectady, N. Y.

K-208 **Ohmite News.** The May 1943 issue describes the application of Ohmite Rheostats in Boring Mill Speed Control. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

K-209 **Aircraft Power Relay.** Bulletin 703, 8½" × 11", 1 page is designed particularly for aircraft power circuits. It will perform at high values of acceleration of gravity and also under condition of vibration and shock. Ward Leonard Elec. Co., Mt. Vernon, N. Y.

K-210 **Micro Switches for Aircraft.** Catalog 70, 8½" × 11", 20 pages describes the electrical and mechanical characteristics of these switches suited to applications on aircraft and aircraft accessories. Micro Switch Corp., Freeport, Ill.

K-211 **Practical U. H. F. Oscillators.** The April 1943 issue of the Cornell-Dubilier Capacitor reprints this article by Robert Ricketts from Radio News. Cornell Dubilier Electric Corp. 1049 Hamilton Blvd., So. Plainfield, N. J.

K-212 **Battery Eliminators for Telephone Service.** Bulletin DL48-156H, 8½" × 11", 2 pages describe Raytheon Rectifilters which provide d.c. power for telephone operation. Raytheon Mfg. Co., Waltham, Mass.

K-213 **Automatic Control.** Bulletin 116, 8½" × 11", 16 pages describes completely the basic problems involved in soaking pit operation. Typical diagrams show the application. A chart showing the properties of typical steel mill gases is included. Heat balance and thermal efficiency is discussed and a heat balance approximation is also included. Askania Regulator Co., 1603 S. Michigan Ave., Chicago, Ill.

K-214 **How to Ship by Air Express During Wartime.** Folder 8½" × 11", 8 pages is an indexed handbook on "Fastest Way Shipping." Railway Express Agency, Inc., 230 Park Ave., New York, N. Y.

K-215 **Strip-Chart Recording Instruments.** Bulletin GEA-1061G covers the general design and features of the Type CD recorders. Specifications covering the models available are included, as well as lists of the ink and inkless record rolls. General Electric Co., Schenectady, N. Y.

K-216 **Rotary Selector Switches.** Folder, 8½" × 11", 4 pages illustrates and describes a number of switches for thermocouples and resistance thermometers. Lewis Engineering Co., Naugatuck, Conn.

K-217 **Navigation Depth Recorder.** Folder, 8½" × 11", 4 pages describes the Simplex-Bludworth depth recorder, an instrument designed to measure and record, on dry facsimile paper, a continuous profile picture of sounded depth along a vessel's course. The system employs supersonic sound waves and precision timing. Bludworth, Inc., 92 Gold St., New York, N. Y.

K-218 **Indicating & Recording Controllers for Temperature, Pressure & Vacuum.** Catalog 1200, 8½" × 11", 40 pages illustrates and describes the various Tag instruments: On-off recorder-controller; full range throttling recorder-controller; and same instrument with automatic reset. C. J. Tagliabue Manufacturing Co., Park & Nostrand Aves., Brooklyn, N. Y.

K-219 **Boundary Protective Equipment.** Folder, 8½" × 11", 4 pages covers a balanced capacitance-operated alarm device designed for use outdoors on property lines either with or without existing fences. Browning Laboratories, Inc., Winchester, Mass.

K-220 **Hot Blast Control System.** Bulletin 27-7, 8½" × 11", 8 pages discusses the control of hot blast temperatures with a single mixing valve. A supplement BF-1 covers the newer furnaces those being modernized, which are equipped with a cold blast valve common to all stoves. The system automatically regulates the mixing valve and/or the cold blast valve to maintain a constant predetermined hot blast temperature. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

K-221 **Valves, Fittings & Hose Assemblies.** Bulletin, 8½" × 11", 8 pages, shows aviation tube, pipe, universal and pipe fittings: automotive and industrial tube and pipe fittings; and refrigeration valves, fittings and accessories. Many of these fittings are very suitable for instrument installations. Weatherhead Co., 300 E. 131 St., Cleveland, O.

K-222 **Cenco News Chats.** The May 1943 issue of this publication has a very interesting editorial entitled "Postwar Science?" It also has an article on Father Julius Arthur Nieuwland and his work in synthetic rubber, as well as other interesting notes. Central Scientific Co., 1700 Irving Park Road, Chicago, Ill.

TO PREVENT WASTE AND AID WAR WORK

(1) Request only the literature that will aid you. (2) Paste the coupon on a government postal card addressed to *Instruments*, taking care to make all four edges stick.

K-223 **Food Dehydration Plant Control.** The May-June issue of Wheelco Comments is devoted to a description of the process showing the application of temperature control. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago, Ill.

K-224 **Connectors, Sockets, Adapters, Plugs.** Condensed Catalog 71, 7½" × 10¾", 12 pages, catalogs and prices a large number of cables, connectors, sockets, adapters, insulation, plugs, cable assemblies, etc. American Phenolic Corp., 1830 S. 54 St., Cicero, Ill.

K-225 **Dynamotors.** Catalog 100, 8½" × 11", 10 pages, catalogs a number of dynamotors for aircraft, marine, police and all mobile radio equipment. Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

K-226 **Allied's Radio Data Handbook,** edited by Lieut. Nelson M. Cooke, U. S. Naval Research Lab. 48 pages, 6" × 9". Price 25c postpaid. This is a condensed handbook of formulae, charts and data most commonly used in the field of radio and electronics. Divided into four parts: Mathematical Data, Radio and Electronic Formulas, Engineering and Servicing Information, and a complete set of four-place Log and Trig Tables. Formulas are given for Decibels, Resistance, Capacitance, Inductance, Reactance, Resonance, Frequency, "Q" Factor, Impedance, Conductance, Susceptance, Admittance, Transients, Peak Average and R.M.S. Voltage and Current Values, Meter Shunts and Multipliers, Vacuum Tube Constants, etc. Data section contains such subjects as Radio Color Codes, Interchangeable Tubes, Pilot Lamps, Plug-in Ballast Resistors, Coil Winding, and others. May be purchased directly from Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, Ill.

K-227 **Mercury Relays.** Bulletin 140, 8½" × 11", 8 pages, illustrates several plunger type mercury relays which have been used in air conditioning controls, remote and automatic controls, photo-electric apparatus, electric time controls, production line time controls, heating and ventilating controls, refrigeration controls, etc. Adams & Westlake Co., Elkhart, Ind.

K-228 **Dial Gages & Precision Equipment.** Bulletin, 8½" × 11", 12 pages, illustrates dial gages, accurate surface plates, angle plates, parallels, V-blocks, and lapping plates for inspection, tool room, layout, production and assembly and general shop use. Lombard Governor Corp., Main St., Ashland, Mass.

K-229 **Spectrographs.** Folder, 8½" × 11", 4 pages lists and briefly describes a complete range of spectrographs to meet the needs of modern industrial analysis and scientific research. Jarrell-Ash Co., 165 Newbury St., Boston, Mass.

K-230 **Pressure Gages.** Catalog A-14, 8½" × 11", 64 pages, starts with a brief history on the development of pressure gages, followed by descriptions of non-corrosive indicating gages, dead weight gage testers and gage board clocks. Star Brass Mfg. Co., 108 E. Dedham St., Boston, Mass.

K-231 **Precision Measurement.** Catalog 31, 5" × 7", 64 pages, price 50 cents, a complimentary copy is available to exec-

Instruments, 1117 Wolfendale St., Pittsburgh, Pa. (JULY 1943)
Please have the following catalogs, etc., reviewed in this issue sent to me.

Numbers .....

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I also desire further information concerning the following new products described in this month's "New Instruments" Department .....

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I also desire further information concerning the following products advertised in this issue (Write page number and name of company) .....

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Company ..... Position .....

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utives requesting it on their letterheads. The instruction section of this handbook is in five chapters devoted to the history of measurement, precision measurement, making gage block combinations, gage block inspection, angle measurement with the sine bar; and the use and reading of vernier calipers and height gages. Photographs of actual operations supplement the text, which is in simple, non-technical language. Following the instruction section is a catalog of the extensive Jansson line of gage blocks, vernier height gages, and vernier calipers. Jansson Gage Company, 19208 Glendale Ave, Detroit, Mich.

K-232 **Liquid Meters.** Catalog, 5" × 8", 40 pages. This complete Bowser catalog has included beginning on page 20: metering equipment, pre-determined meters, container filling equipment, proportioning systems, special meters, rotary type meters, high pressure-temperature meters, etc. S. F. Bowser & Co., Inc., Fort Wayne, Ind.

K-233 **Dynamic Balancing Machines.** Folder, 8½" × 11", contains a number of loose leaf bulletins each of which covers a different model: small bench-size dynamic balancing machine; bench type static and dynamic balancing machine; floor model static and dynamic balancing machines; large model balancing machines. Bear Manufacturing Co., Rock Island, Ill.

K-234 **Time Pattern Controller.** Bulletin 87-1, 8½" × 11", 8 pages, describes in detail the operating principle of this two-unit Time-Pattern Controller: (1) The Pattern transmitter and (2) the control instrument. The text is fully supplemented with diagrams and illustrations of installations. A section is also devoted to a description of applications and the advantages to be obtained by time-pattern control of manufacturing processes. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

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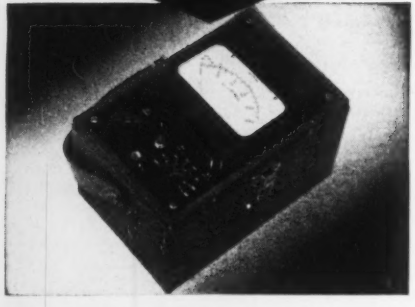

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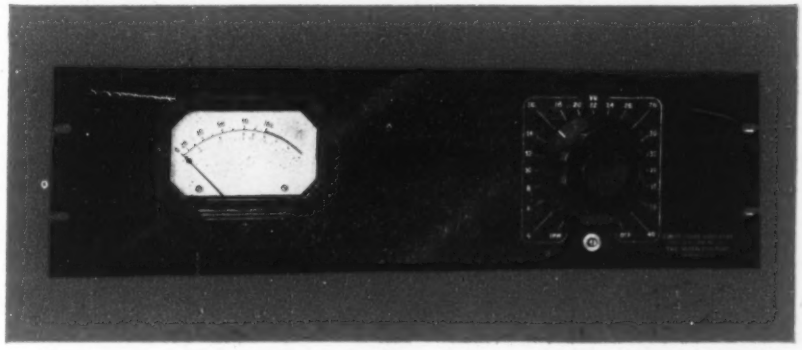
He must have it . . . first!

Daily production schedules are determined only on the basis of preference ratings indicated on priorities extension certificates. At times, this fixed arrangement must "stretch" to accommodate later urgency directives. If an occasional shipment has been delayed beyond our estimated delivery date, it is only because a MORE VITAL order has intervened and has preceded it.

Though we are indebted to clients who have favored us with their patronage in previous years, our personal preferences are subordinated. We rightfully are proud of the fact that these clients, who advised and assisted with many of our pre-war engineering developments, are sharing today's inconveniences with the same friendly cooperation.



Ordering standard components and equipment may facilitate deliveries.

THE DAVEN COMPANY

191 CENTRAL AVENUE • NEWARK 4, NEW JERSEY